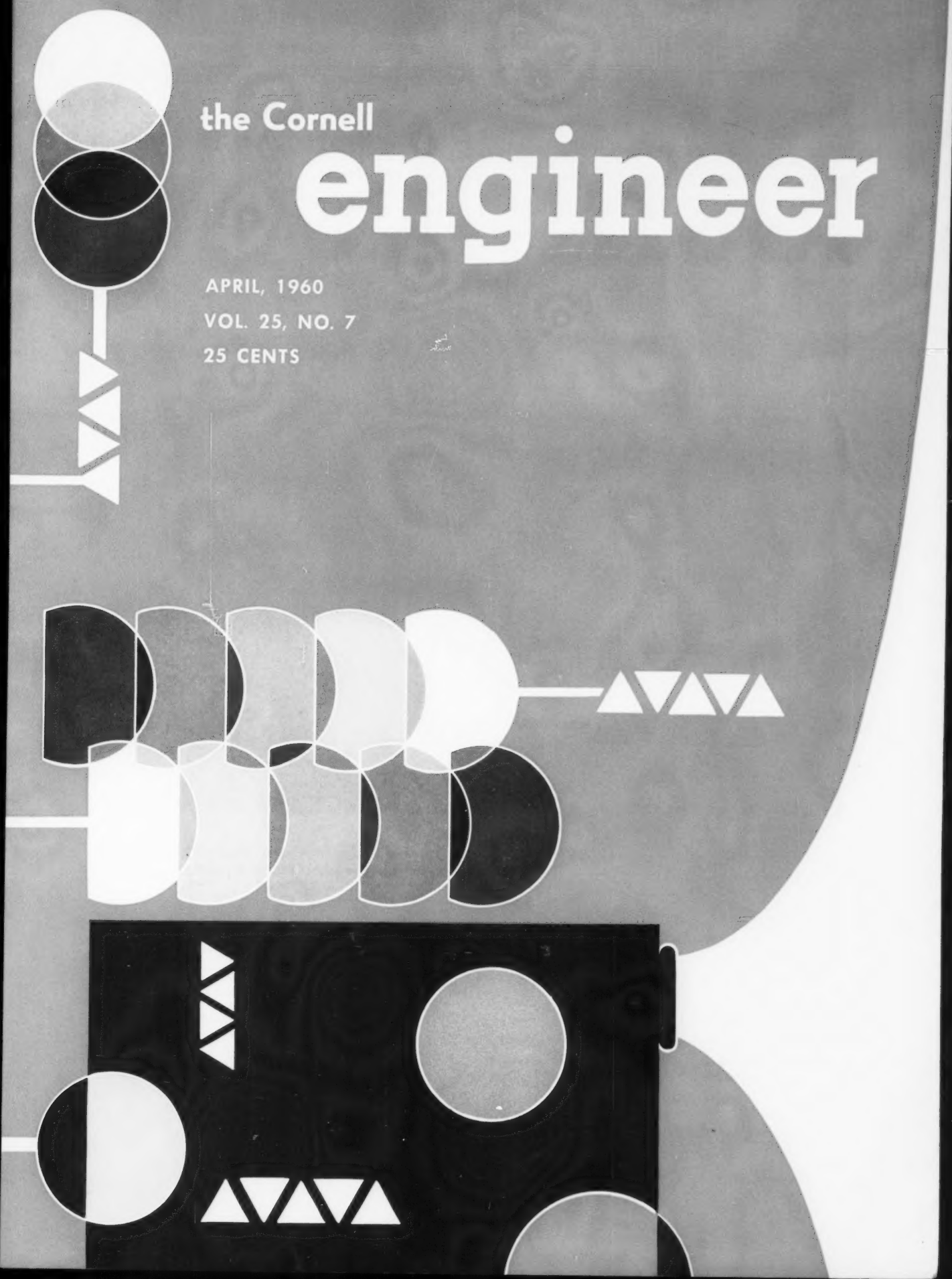

the Cornell engineer

APRIL, 1960
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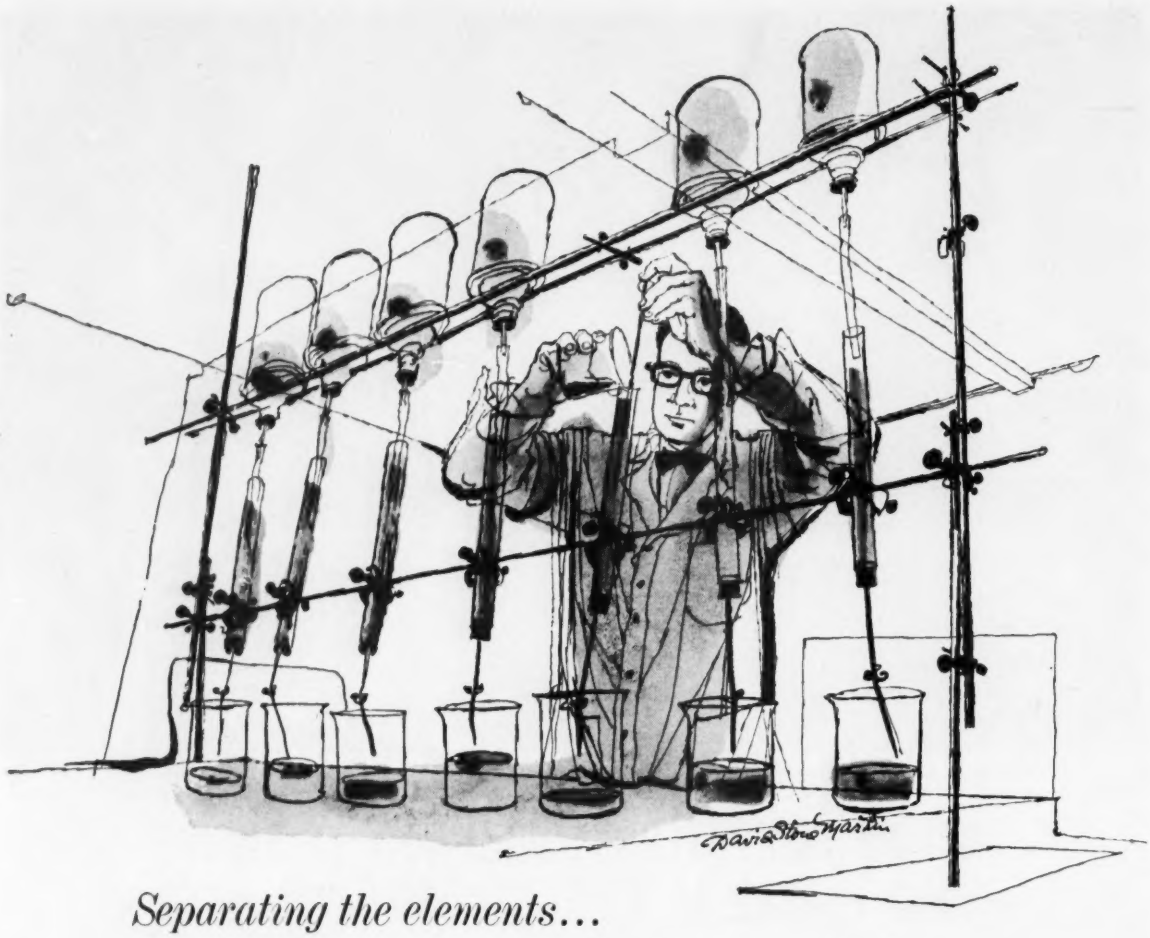

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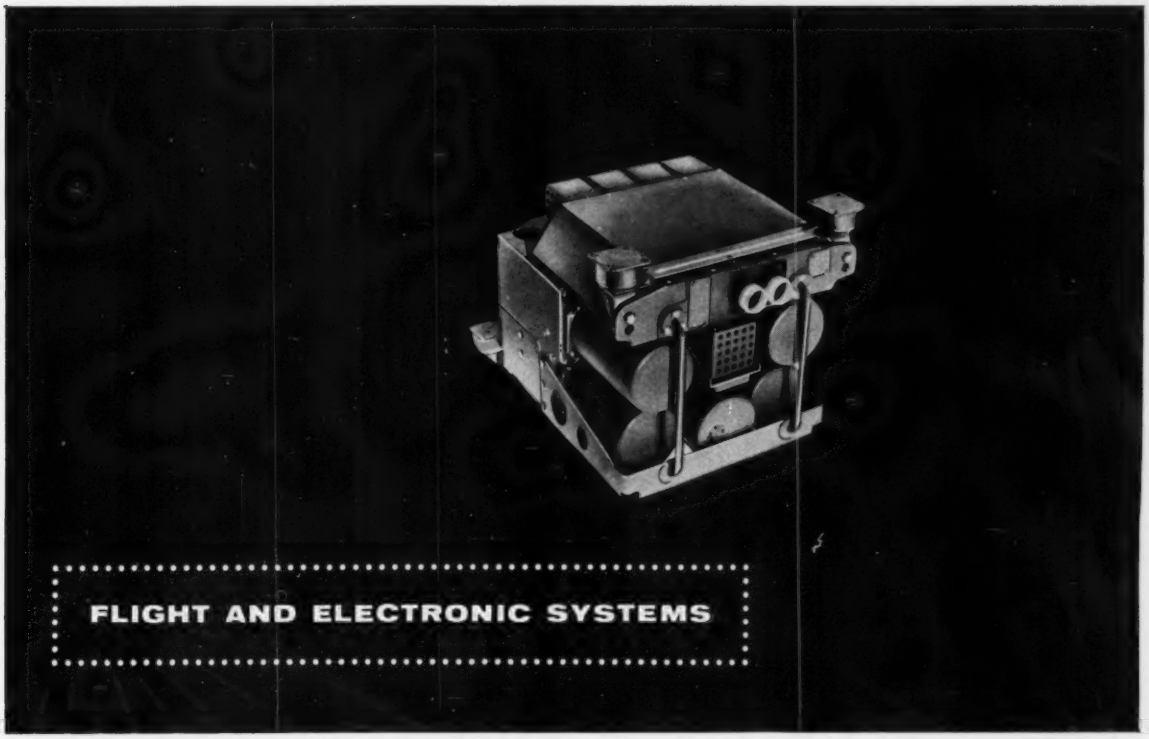

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Editorial . . .

EFFECTIVE TUTORING PLAN REQUIRES ADDITIONAL FUNDS

For the past two and one-half years the College of Engineering has conducted a program of tutoring aid in order to reduce the number of freshmen failures in the engineering school. Two tutors were assigned to each dorm five nights per week; one for math, and the other for physics. Approximately sixty-one upperclassmen of the college were employed each of the first two years. Each tutor spent one night a week in the dorms. The program, which was originally made possible by the gift of an anonymous donor, has now been discontinued because of the exhaustion of the original fund. The effectiveness of the program indicates that it should be continued.

Evaluation Under Way

The college is now collecting data in order to evaluate the program. The results collected so far have shown that while the physics program was apparently not effective, the math program was. During the period for which tutoring was made available the number of failures in physics was not significantly reduced. The number of people failing math, however, was reduced by more than half each fall term, while no greater number failed in the spring. In the year before the tutoring program sixty-two people failed math 161. In the next years twenty-three, sixteen, and thirty, respectively failed. Furthermore, of those students failing only a few had been to see the tutor; none more than three times.

When we consider the difference in the results obtained in math and physics, one of the first things that comes to mind is the frequent complaining of freshmen about the quality of instruction received from the math department. This seems to substantiate their complaints. We hope that this situation will be corrected soon!

Another probable cause for the success in math and not in physics is a very basic difference between the two courses. In math the student may apply the methods of solution learned in a homework problem to an exam problem, but in physics he must apply the basic principle underlying homework problems. In the latter case the method of solution learned in his homework problems may not apply. Many students received help with physics problems, understood the methods of solution, but still did not attempt to understand the underlying principle. In light of these considerations, the greater effectiveness of the math tutoring is not surprising, and it would seem that only the math program should be continued on a full scale.

Further Benefits

The tutors are in a position to do more than instruct the freshmen in problem solving and clear up misconceptions in theory. They are able to ease freshmen into college study habits and mature attitudes toward academics. Tutors reported that they showed freshmen how to regulate their time, use study techniques and balance their schedules. This was perhaps more valuable than any amount of extra course instruction could have been.

In evaluating the program one must not forget that the tutors themselves benefited. The program provided financial aid, as well as teaching experience, to qualified engineering upperclassmen. Since its inception approximately 150 tutors have participated. Each of them has had an average above 83 and has demonstrated great ability in the subject he tutored. Most important, one third of the tutors are considering teaching as a profession, a large percentage of them as a direct result of having tutored. The experience obtained, and the interest aroused in the teaching profession are valuable by-products.

Program Should Be Continued

In light of its effectiveness and its many other benefits, we feel that the math program should be continued. Experience has shown that utilization of the program was much lower in the spring than in the fall. This is partly caused by the availability of help to the large number of freshmen who join fraternities and also by the increased self-confidence of the freshmen. For this reason it should be sufficient to limit the program to the fall term.

The cost of continuing this program is small in terms of the great benefits it offers. Unfortunately the University's heavy financial commitments will not permit an appropriation to assure its continuation. It is our earnest hope that some of our alumni will see the important benefits of the tutoring plan and provide the funds needed for its support.—R.T.F.

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THE CORNELL engineer

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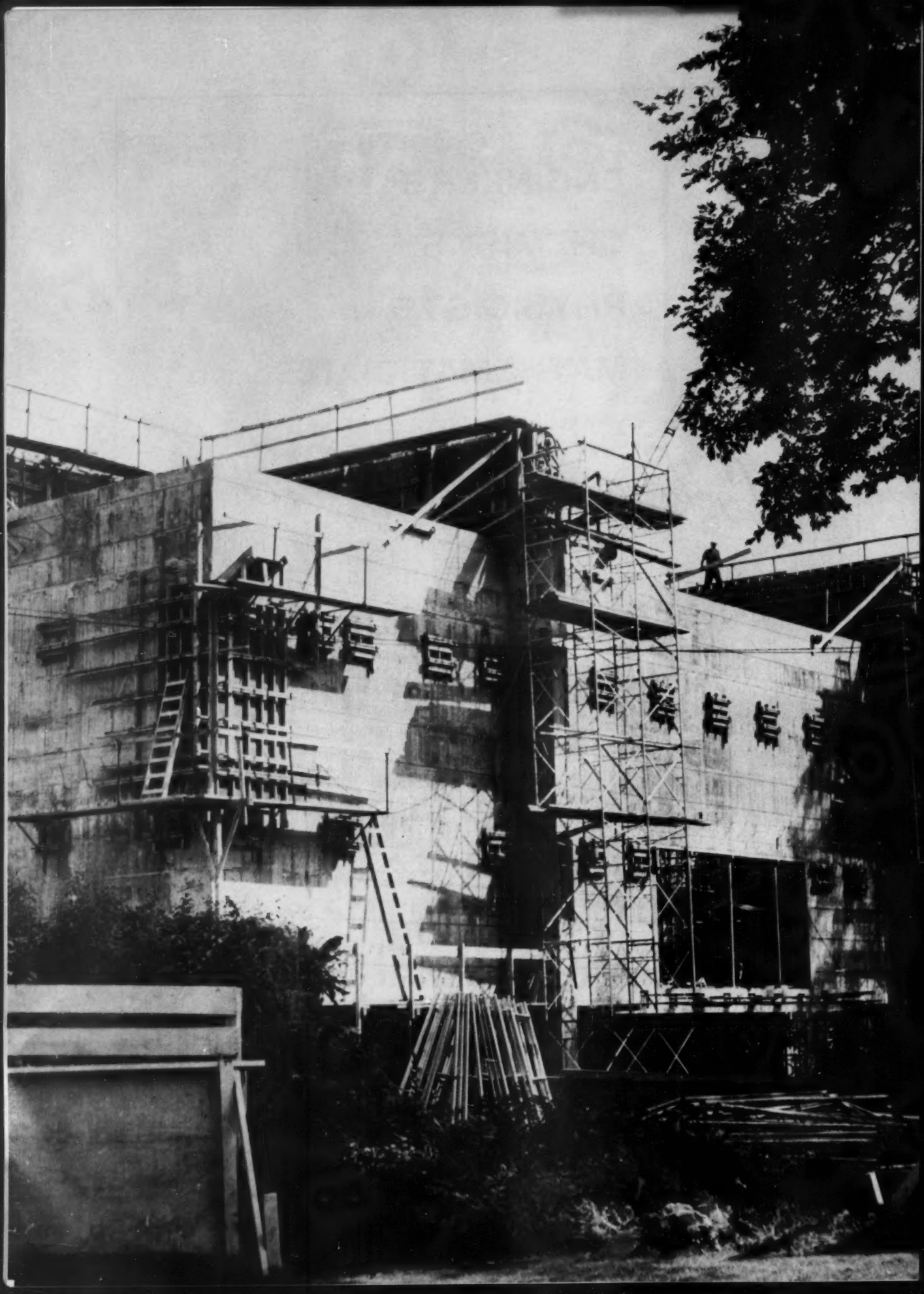


Designed by a Cornell alumnus, Utica's new art gallery features . . .

NEW TECHNIQUES IN CONCRETE CONSTRUCTION

by Warren H. Sears

The first structure utilizing monolithically intersecting concrete girders is now being built in Utica, New York. This building, the Munson-Williams-Proctor Institute Art Gallery, is a triumph in engineering skill and architectural ingenuity. Its story is a fascinating one of engineering adaptions to meet a new challenge. When finished, the building will be a tribute to the ingenuity of its builder, Dr. Lev Zetlin, Cornell '51, and its designer, Philip Johnson.

Rising out of a 10-ft. deep grass moat to a height of 52 ft, the 117-ft square reinforced concrete structure is a lesson in provokingly simple beauty and engineering.

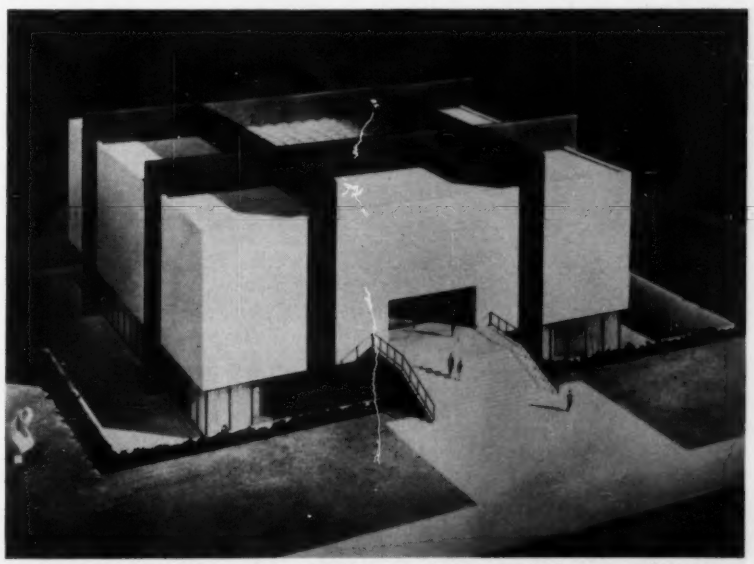
Four huge, post-tensioned concrete girders, supported only at their ends by eight exterior columns, intersect at four points across the top of the building. Deceptively simple in design, their sharp, crisp pattern provides a structural system that eliminates the need for any interior columns above the main floor and makes possible a completely unobstructed auditorium and a main gallery with a 30-ft high ceiling.

The choice and design of this "two-way lattice girder system" was a bold, pioneering stroke. While its principles are known and well-documented, the M-W-P Institute Art Gallery represents its first significant application anywhere. Yet its use in this structure has been no mere experimental flirtation with the strength of materials. The advantages accruing from its employment represent a significant improvement over what has been done before in this field.

Design Advantages

The four *intersecting* girders provide a strength and stiffness equal to eight parallel girders of approximately the same size; or sixteen 2 ft x 2 ft interior columns. Economically, the two-way system represents a saving of roughly $50,000; aesthetically, it provides a vast expanse of free, uncluttered space throughout the main section of the building; and engineering-wise, it has meant less deflection, more uniformly distributed, and greater strength in the entire structural system.

In addition to supporting the precast concrete roof, the girder system also partially supports a 30 ft wide balcony that hangs below the roof. Four 2½-in. thick steel



Original model of the museum highlights its classic, simple beauty and ingenious structural system.

Form work on corner of building indicates section at wall left unpoured for three months, later filled to compensate for shrinkage.

rods threaded into each girder provide overhead support for the balcony.

The superstructure walls of the building act as deep cantilevered girders supporting part of the roof, part of the balcony and part of the main floor. A total of 648 cu. yd. of lightweight concrete went into the forms for the four walls, which were poured monolithically with the exterior columns.

The walls of the structure, though they appear to float on the thin ribbon of glass that completely surrounds the ground floor of the building, are actually supported 11 ft above the ground level. Here the columns project into the building, forming an exposed foundation.

Once concrete for the walls and eight exterior columns had been placed and stripped, forms were constructed for the intersecting girders. Actually, when they were through, workers had built one huge, elaborate form, looking like the beginning of a gigantic game of tic-tac-toe.

Supported by shoring, or temporary supports, the form was filled with a variety of hardware necessary for reinforcing the concrete, including ¼–in. reinforcing steel bars, ⅜–in. reinforcing stirrups, 4–in. diameter hollow sleeves for balcony rods and–into each girder form – fourteen hollow, flexible, steel, post-tensioning conduits anchored at each end of the girder and draped in smooth parabolas. Each girder form was jacked up to form a 2 in. camber, or rise, at its center to allow for deflection under the weight of the concrete; then the concrete placing was ready to begin.

Concrete Control

Concrete for such a sustained and intricate pour required fastidious attention to its design and special care in its preparation and handling. Five principal factors influenced the requirements and specifications for the mix design. First, to meet the prescribed design loads of the structural system and to utilize pre-stressed concrete economically, the concrete had to have a compressive strength of 5,000 lb. per sq. in.

Second, the post tensioning pressure to be applied to the girders precluded the presence of horizontal cold joints or voids which would reduce the compressive strength of the girder.

Third, to insure a completely monolithic member, the set of the mix had to be retarded by three hours.

Fourth, because of the complex arrangement of reinforcing steel and delicate cable conduits in the forms, the mix had to have a high degree of workability.

And finally, Zetlin wanted as much early deflection as he could get so that the girders would obtain all of their deflection at the earliest stages of construction.

These factors required sharp reduction in the amount of water and cement that would normally be prescribed, without reducing the needed workability of the mix.

All concrete mixing was closely controlled and was pre-determined by trial mixes approved personally by Dr. Zetlin. Samples were taken and examined frequently to insure that the required strength specifications were being met. Modulus of elasticity tests were also performed on the concrete to determine expected deflections of the members.

On the day of the actual pouring, concrete placement for the girders began at 8 a.m. with two crews and two cranes starting in adjacent corners and working right across the top of the building. At 5 p.m. an additional crane and crew joined in. The operation was completed shortly after midnight. Concrete was hoisted to the top of the building by crane, in 1-yd. bucket loads, and eased into the forms through elephant trunks. A total of 350 cu. yd. was poured in 16 hrs.

What ultimately went into the great, criss-cross form was a highly workable mix that produced a strength in excess of 5,000 lb. per sq. in. A 20 per cent reduction in water content of the mix induced early development of creep, a girder system free of cracks through minimum drying shrinkage, and a completely monolithic member through controlled rate of hardening.

Shrinkage Cracks

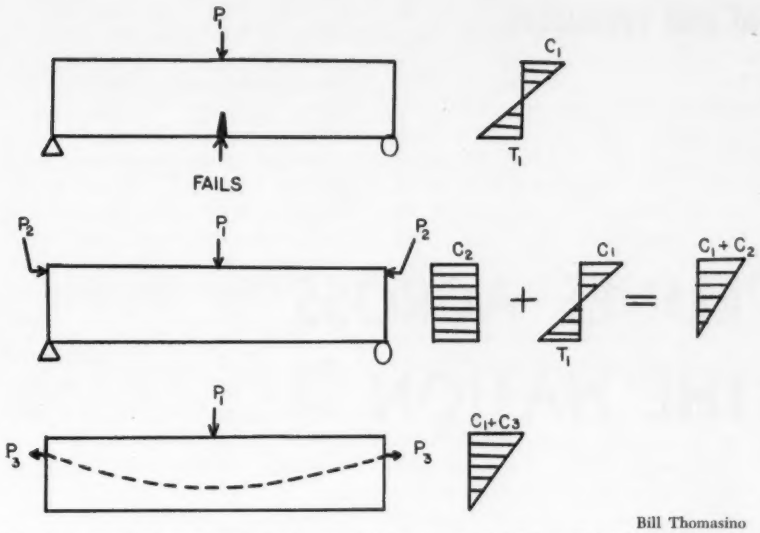
Zetlin attacked the problem of shrinkage cracks, not only in the girders through the use of the admixture, but in the building's decks. A 3 x 30 ft area in the corner of each floor was left unpoured for a two-month period, during which time almost all shrinkage occurred. The open sections were then concreted, leaving a perfectly crack-free system of floors.

The same technique was employed in the placement of the superstructure walls, with a 3-ft wide corner section left open the full height of the walls in all four corners and filled 60 days later.

Other openings in the concrete superstructure walls–later filled–were also left to permit easy placement of the concrete for the balcony.

The exceptional strength of the intersecting concrete girder suspension system is derived from its

Bottom corner of the superstructure wall is a 30 ft. cantilever. The 11 ft. high opening will be a full glass wall.



Bill Thomasino

(Top) An unreinforced concrete beam, subject to a load (P_1), will fail due to tensile stresses at its lower edge.
(Middle) The same beam, when subjected to an axial compression load (P_2) will be under the influence of two stress distributions which may combine to produce compression stresses only.
(Bottom) The post-tensioning process cables, which were draped parabolically in the forms before the concrete was placed, are stressed after it has set. This produces a tension-free stress distribution similar to that shown in the middle view.

unique design and from the great stress placed in the girders through post tensioning, a process which overcomes concrete's great weakness—its almost negligible strength in tension (see Fig. above).

The post tensioning process produced girders free from tension stresses and capable of supporting themselves, the roof, and the hung balcony.

With tensioning completed the conduits were completely grouted with a sand cement grout.

In accepting the commission to design the new museum, Philip Johnson, one of the country's most distinguished architects, named flexibility and intimacy as two of his main goals for the structure. "It has to inspire a feeling of a cathedral," he said, "yet be as intimate as a cottage." He noted that a person must never be more than one room away from the central main gallery. The visitor must not have a feeling of being lost in a labyrinth.

"The problem" he said, "is to have space to hang paintings and at the same time make the museum a pleasant place for people to congregate. A museum should not just be a depository of art but also a community center. The modern museum should be the center of the cultural life of a town and the buildings designed to house it should encourage this use for all the arts including music."

When completed the exterior concrete walls will be covered with approximately 1,500 blocks of Black Canadian Granite, from the northern Hudson Bay area.

Interior Design

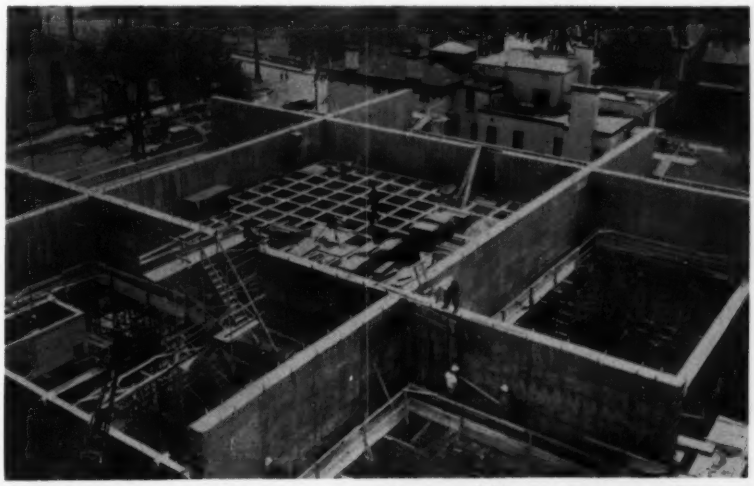
The columns and girders will be sheathed in bronze, to provide a striking contrast against the textured dark gray stone. Floors of the balcony and main exhibition room will be covered with Italian Travertine marble, with all other floors to be Terazzo topped. The ground floor windows, which provide the ground floor rooms and offices with one complete glass wall, will be framed in dark gray painted aluminum.

Heavy teak plywood will be used on the walls in the lobby and main hall with vinyl on all the office wall surfaces. Pandanus cloth, a material that will conceal holes made in the hanging of the changing exhibitions, will be applied to all the gallery walls.

Included in the design are a 300 seat auditorium on the ground floor, two exhibition floors for painting and sculpture, office space, and fireproof storage. A roadway to the ground floor will permit delivery to storage and access to the office area. Plans also call for large off-street parking facilities and landscaped grounds.

The building has no actual street level. The ground level rests in the 10-ft. deep moat; while access to the main floor is gained by steps leading up from the street.

The builders have succeeded in creating a truly functional and beautiful structure, one which makes use of both engineering and architectural innovations. It is a living illustration of Dr. Zetlin's philosophy—that if a building is beautiful to the eye, it is structurally sound.



These four intersecting girders form a complete monolithic concrete structural system and eliminate the need for interior columns in the main gallery.

Our vast oil and natural gas resources demand a network of . . .

PIPELINES ACROSS THE NATION

by Theodore Spar, CE '62

Pipelines are the main means of transportation for natural gas, petroleum, and petroleum products. Today, close to 700,000 miles of pipe span practically the entire country in a network unequalled in any other nation. Since the late 1800's new lines have been built and old lines have been expanded at an amazing rate. To keep up with the increasing demands of our industrialized society, new methods and equipment are being steadily applied to this field.

Pipelines have been used for the transmission of fluids for thousands of years. The Chinese were using bamboo pipe water lines in 5,000 B.C. and had a natural gas pipeline in about 900 B.C. The Roman Empire developed a water system capable of handling 332 million gallons a day in small diameter lead pipe.

Early Construction

History of oil pipelines began almost with the drilling of the first well. The early wells were in areas of rough terrain, many miles from the nearest railroad or canal. Oil was initially hauled in barrels by teamsters to the nearest depot. The first attempts at construction of a pipeline ended in failure—not because of mechanical short-comings but because of attacks by teamsters. Owners and drivers of the oil wagons realized that the pipeline could put them out of business. The outbreaks were soon quelled by use of armed force.

In 1865 Samuel Von Syckel of Titusville, Pennsylvania built a line which, although it only carried eighty barrels a day, demonstrated the practicality of this means of transportation. This success led to the building of other lines to local refineries and to railroads taking the crude oil out of the region.

The railroads at first welcomed the added revenues received from the freight traffic that resulted from pipeline construction work. They realized, however, that pipelines were a threat to their own tank car business. Railroads resorted to powerful lobbies and physical violence in an attempt to stop the building of pipelines, but the overwhelming economy of pipe-

The Petroleum Pipe Line System in the United States.

line transportation won out. The economic advantages of pipelines over railroads are easily seen: With a pipeline there are no empty cars to make a profitless return trip; maintenance costs are low; labor force required to operate a line is small. For these reasons pipelines spread quickly. By 1900 there were approximately 18,000 miles of crude oil lines radiating from the Pennsylvania oil fields.

Rifled Pipe

Major advance was made in 1906 with the introduction of rifled pipe. Transport of more viscose crude oil now became possible. The interior of this pipe is lined with spiral grooves. Oil plus a small amount of water is introduced into the pipe, and the rifling sets the mass spinning. The water, being heavier, goes to the outside and forms a lubricating film around the oil. This device substantially enlarged the class of materials which pipelines could carry.

The extensive pipeline system allowed the use of a relatively few large refineries in seaboard areas instead of the countless smaller ones which had been in service.

Power for petroleum pipelines is provided at pumping stations along the route. The earliest pumps were driven by steam engines. Horizontal air-injection-oil-engines came later, and vertical diesels are used in most pumping houses today.

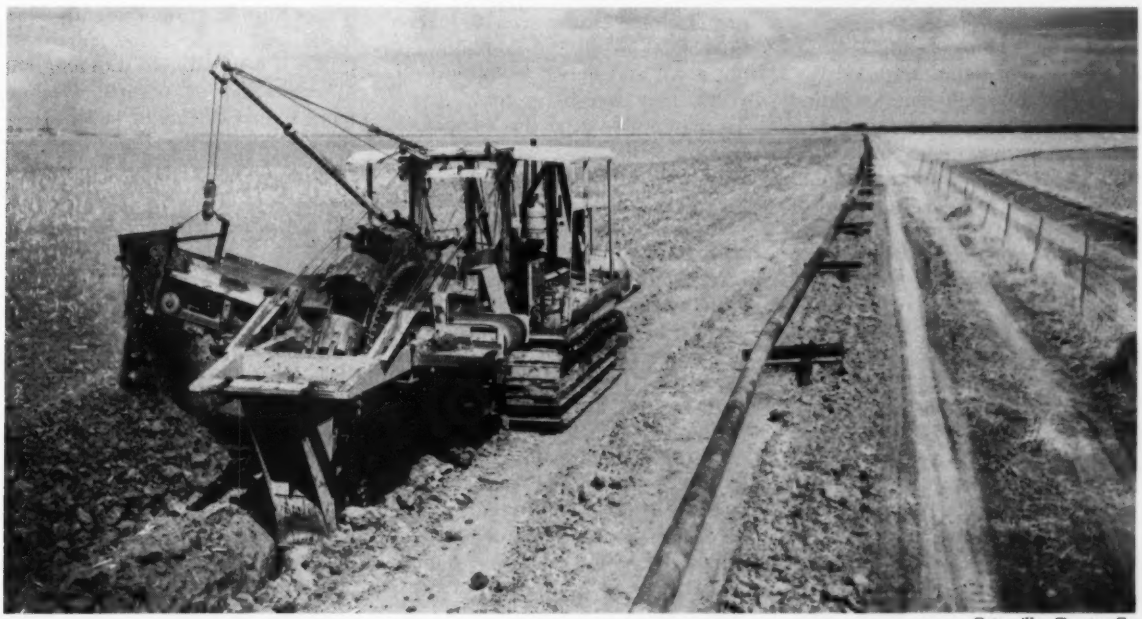
There are in general two types of petroleum pipelines—gathering lines which take the crude oil from wells to tank yards, and trunk lines which carry it from tank yards to ports or refineries. When carrying refined petroleum products, trunk lines are usually known as product lines. A product line may carry several different oil derivatives at the same time, each of different ownership and composition. Each batch merely "pushes along" the one in front of it with negligible mixing between batches. Product flow is at the rate of about 4 mph. It is the control center's job to know where the face of each batch is so that it may be switched off the line at the proper time. The most modern method of following a batch employs radioactive isotopes at the beginning of each shipment and radiation counters along the line.

In 1955, product lines in the United States totaled 24,000 miles as compared with only 1,300 miles in 1930. This tremendous increase is due in no small part to increased demand during and after World War II. The Big Inch and Little Big Inch lines were built as war time measures because of the danger from enemy submarines to tankers making the trip from the Gulf of Mexico to East coast refineries. By 1955, the total crude oil linage (including gathering and trunk lines) equaled 170,000 miles.

Natural Gas

The progress of natural gas and petroleum transportation have been similar but not parallel. Gas had been used on a local scale for many years. However, attempts to increase its use failed due to a lack of proper type pipe. The common pipe material, cast iron, is in most cases too heavy and brittle for cross-country work. It is still used to a limited extent on low pressure short runs. In the 1830's a wrought iron line was attempted, wrought iron being lighter and tougher than cast iron. However the major problem of leakage still existed. This was not solved until 1891 when an oil well equipment manufacturer, Solomon Dresser, developed what has come to be known as the "Dresser Coupling." This consists of a center sleeve into which the two pipe ends fit, along with two follower rings with equally spaced bolt holes, and a special rubber gasket which expands when the bolts are tightened to produce a leak-proof joint.

Steel pipe had been recognized as the best for cross country runs.



Caterpillar Tractor Co.

This modern trench digging machine seems to be faced with a never ending task in preparing the ditch for a natural gas pipeline in northern Texas.

Caterpillar Tractor Co.

A river crossing, one of the more difficult of pipelaying operations, is greatly facilitated by the use of modern construction methods. Note the use of the side boom tractors, large diameter steel pipe and long preassembled sections.

However until the advent of the Dresser coupling it could not be used in large enough diameters to be economical. Pipeline economics are such that per barrel-mile the cost of a 20 in. line at full load is 40 per cent of the equivalent full load on a 10 in. line. The new coupling allowed the use of the more economical, larger diameter pipe. This coupling was also designed to allow for a 1-degree deflection in each pipe, thereby reducing the amount of pipe-bending necessary to negotiate slight curves. In 1920, oxyacetylene welding replaced the Dresser coupling as a means of joining pipe on all long runs. By 1928, electric arc welding was the main process used for this purpose. X-rays and radioactive materials have been introduced to inspect the quality of metals and welds.

Modern Developments

The discovery of large gas fields in the southwest during the late 1920s and early '30s, plus an increase in demand, gave pipeline construction a boost which it still feels today. These increased demands for pipelines caused a minor revolution in pipe laying practices. Until this time, pipelines were built on a trial and error basis. When necessary, pipe was bent by "snubbing" it around a tree, or by having the crew repeatedly jump on it. If the pipe was too large in diameter for this, it was suspended over a ditch and heated until it sagged into the desired shape. Today pipe-bending devices cold bend pipe up to 36 in. in diameter without introducing dangerous stresses.

When smaller length and diameter pipe were common, it was possible to handle the pipe by man power alone. However, a 40-ft section of 30-in. pipe, a combination not at all uncommon in the last 20 years, may weigh up to 2½ tons. To manipulate pipe this size, steel tripods with hand winches, and, later, side boom tractors, were introduced.

From the outset, it was necessary to maintain communications systems along the pipelines. The early systems used telegraph lines parallel to the pipe to connect control centers and telephone booths along the right of way. From these, line walkers could report leaks, washouts, or other undesirable conditions. The pipelines made use of radio and microwave transmission as soon as these became available. In modern control centers, remote control operation of pumps and compressor stations miles away is not unusual.

Compressor stations are generally located about every 80 miles along natural gas lines. Reciprocating gas engines provide the motive power in most stations today, but steam engines were used originally.

Regulation

Unlike natural gas lines, oil pipelines are regarded as "common carriers" under the Hepburn Act of 1906, an amendment to the Interstate Commerce Act. This means that a pipeline is required to carry the oil of any shipper who meets the company's published tariffs. These tariffs, which must be filed with the Interstate Commerce Commission, usually include transportation rates and minimum quantities accepted for shipment and delivery. These minimum requirements have in most cases been too high to allow pipelines to function like true common carriers. Over the years very few formal complaints have been made to the ICC concerning rates. However, informal complaints which have been made suggest that rate conditions are not ideal. Pipelines are presently dominated by a few large companies which haul almost exclusively their own products. The small refinery has not benefited from pipelines as much as rate and mileage figures indicate.

In its youth, the pipeline industry fought the railroads and teamsters; during its development, it battled terrain and the elements. However, it continues to grow. Presently, due to efficient methods and volume of traffic, it is possible to ship a gallon of crude oil or refined gasoline more than 1,000 miles at less than the cost of sending a post card the same distance.

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Compact, light-weight, low-cost electronic equipment has resulted from the use of . . .

SEMICONDUCTORS

by Joel Lichtenstein, EE '64

Today's electronics industry is one of the fastest growing, most competitive in the country. Dating back to Lee DeForest's invention of the audion vacuum tube in 1906, electronics equipment has become the mainstay of the country's defense as well as the housewife's kitchen. A study of the basic theory of electron tube operation and the realization that transistor and semiconductor devices have revolutionized the industry in the past decade, give one an idea of the growth that has taken place in the field since 1906.

Theory of Operation

Certain materials, when heated in a vacuum, tend to lose electrons in much the same manner that molecules evaporate from heated water. This thermionic effect was discovered by Edison during his work with incandescent lamps. It is basic to the electron tube, in which a heated filament causes a grounded metallic strip, or cathode, to emit electrons. If another plate is inserted in the evacuated tube and made positive with respect to the cathode, the plate will attract the cloud of electrons leaving the heated element, and a current will flow across the vacuum. This current is a non-linear function of the voltage between the plate (anode) and cathode, and is affected by many variables such as emitter material, heat, and stray electric fields. If the voltage polarities are reversed, no conduction can occur, since the unheated anode cannot emit electrons. Thus the tube will conduct in only one direction and an a-c input current emerges as pulsating d-c.

If a grid of fine wire or screen is inserted between the cathode and the anode and a voltage, negative with respect to the cathode, is applied, a field is set up which tends to hinder the electrons being accelerated toward the plate, and thereby the plate current is controlled. Thus the current flowing across the tube is proportional to the grid bias. Small variations (such as radio antenna currents) applied to the grid cause identical variations in the much larger plate current. In the circuit shown in Fig. 1, a small amount of the oscillating power of the resonant circuit in the plate is applied through a stepdown transformer to the grid, setting up a self-sustaining oscillator. In practical applications another resonant circuit is put in the grid circuit and self-generated oscillation occurs when the two are properly tuned.

This simple type of control is basic to the electronics industry. With the addition of other control grids and specialized types of vacuum tubes, high power radio transmission and reception, computers, radar, TV, and many other modern electronic "miracles" are possible.

Serious Drawbacks

In recent years, however, the wonderfully useful and versatile vacuum tube has proved to be the chief bottleneck to electronic progress. First, tubes are relatively short lived. Filaments eventually burn out, cathodes lose emissive powers, and shock and vibration ruin the delicate electrode supports causing internal shorts. This chance of tube failure becomes acute in modern apparatus involving thousands of tubes.

Secondly, miniaturization of equipment is limited for reasons other than the obvious one of tube element size. Heat is a prerequisite of operation. Dissipation of this heat prohibits closely packed tubes and components, and necessitates

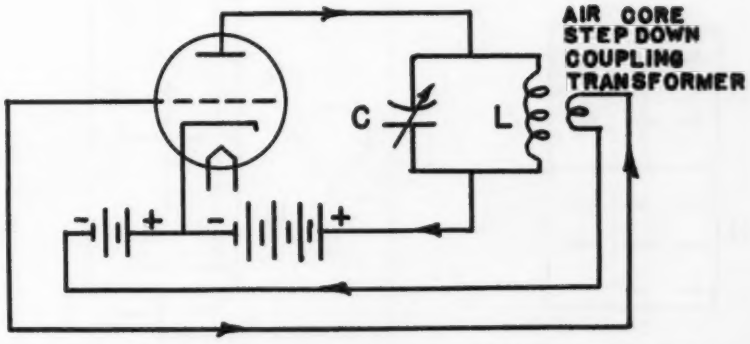

Fig. 1. **The schematic diagram shows a triode vacuum tube circuit set up to operate as a feedback oscillator. "L" and "C" comprise a resonant loop which controls the frequency of oscillation.**

tube envelopes large enough to radiate it, or the alternative of heavy forced ventilating systems such as those used in computers and transmitters. The need for high current filament power and, often, several regulated grid voltages as well as a high voltage plate supply necessitates heavy, bulky power supplies and associated regulating circuits.

Now, more than fifty years since DeForest's invention, a new device is rapidly taking over many of the functions of electron tubes. The work on semiconductors since World War II and the development in 1948 of the transistor have helped to solve many of these problems along with countless others. The most obvious advantage of semiconductors is their relatively small size, but this is only the beginning. Semiconductors have the great advantage of not using Edison's thermionic principle. This eliminates the filament and its power supplies, heat and ventilation problems, high power consumption, warm-up time, and problem of burn-out. The basic nature and construction of semiconductor devices gives them an unlimited life expectancy. All parts are small, light, and firmly attached, so shock is not an important consideration. Along with increased reliability and the possibility of miniaturization is the advantage of lower total equipment cost.

Classification of Materials

Solid state materials are commonly classified as conductors and non-conductors (insulators). Conduction is made possible by the presence, as in copper, of relatively loosely bound valence electrons which are available to conduct current through the material in a sort of chain reaction. Substances such as diamonds are bound by strong double electron bonds in all directions. This makes use of all valence electrons and leaves none for conducting current.

There are, however, a few materials, principally silicon and germanium, in which the number of atomic electrons does not quite match the number needed to produce the normal crystal lattice. These materials are called semiconductors. If there are extra electrons, these are free to conduct current much like the electrons in a vacuum tube. A specific semiconductor crystal may also have a lack of electrons or, as it is said, an excess of holes. In this case, as an electron from one atom moves to fill the hole in another, its departure leaves a corresponding hole in the donor's electronic structure. This effect maintains itself when a voltage is applied; thus, a material may conduct by means of holes as well as by electrons. A material possessing excess electrons is called "N" type material, while one with excess holes is called "P" type material.

If a piece of P material is joined to a piece of N material and a voltage is placed across the junction, as shown in Fig. 2, the N electrons are attracted across the junction to the positive connection. In the same way the holes progress to the negative pole, and a current flows through the device. If, however, the voltage polarity is reversed, the electrons and holes are attracted away from the junction and no current flows except for a small leakage. Thus a very small component can be constructed with properties similar to those of a vacuum tube rectifier, which requires no heating filament, and is independent of shock and vacuum problems.

Semiconductor Problems

There are, however, several problems involved in semiconductor junction devices. The transition time for the electron and hole migration is finite. This, together with the capacitance effect of extremely closely spaced semiconductor junctions, restricts the upper usable frequency limit. Also the heat produced by large currents causes variations in the conductance properties of the junction.

The capacitance problem can be overcome by using N type crystal for the main body of the device. A small P region is then formed under the external lead connection. This point contact technique greatly limits the power-handling capa-

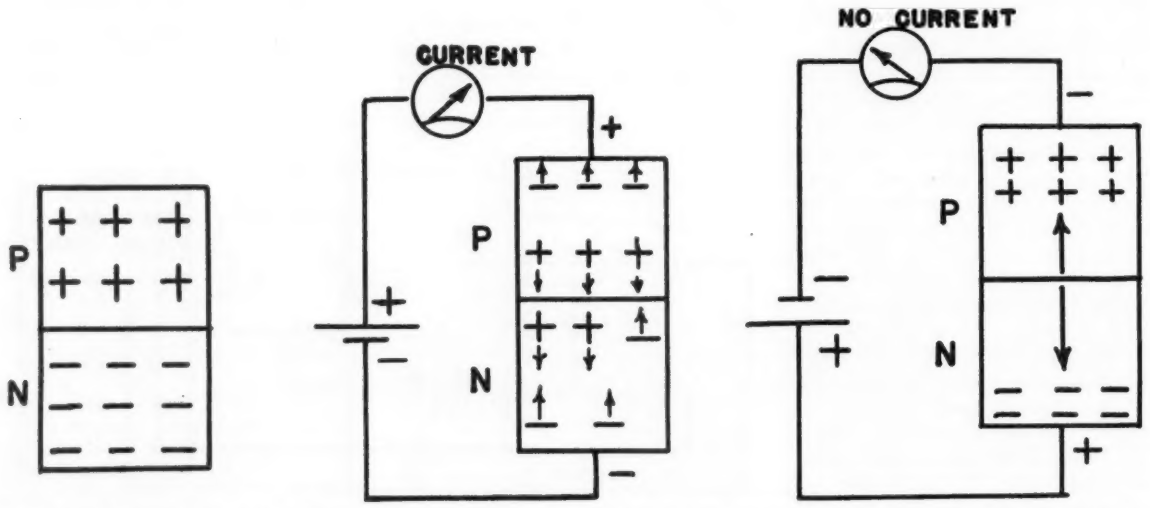

Fig 2. A P-N junction or diode is diagrammatically shown here under natural conditions and under the effects of voltages of opposite polarities.

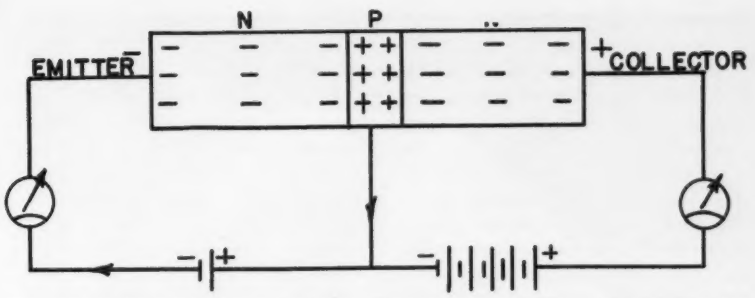

Fig. 3. **The simplified diagram of a transistor illustrates the sandwich construction principle. The center element, or base, is common to both circuits.**

bilities of the device, so the junction technique is most frequently used in diodes and transistors for low power receiver and computer circuits.

Semiconductor diodes are rated by their maximum forward current, forward resistance (about 50–200 ohms), back resistance (usually over 1 megohm), maximum operating temperature, and peak inverse voltage. This refers to the back voltage at which the reverse current becomes intolerable. For a normal a-c circuit the peak inverse voltage is the same as the forward voltage. A diode rectifier was recently introduced that is smaller than a thimble and is capable of handling 20 amp at 220 C and 300 v with a forward resistance of only 1 ohm.

Transistors

A transistor is a semiconductor device employing two junctions. It may be visualized as a sandwich of one type of material between two slabs of the other type, as in Fig. 3. In effect it consists of two N-P junctions back to back. The sections are called the emitter, base, and collector from left to right as shown in the diagram. The section on the left (emitter) is biased to conduct in the forward direction, and the collector-base P-N connection is biased with a much higher voltage for reverse current.

As electrons from the emitter enter the base section, a few are neutralized by the excess holes in the base. If, however, the P base section is made very thin, most of the electrons will approach the area of the base collector junction. They will be attracted across the junction by the very high collector voltage. They then enter the collector circuit and add to the small reverse current already present.

By using a higher voltage on the collector than on the emitter, the reverse collector current plus the current of electrons passing across the base-collector junction can be made nearly equal to the emitter current. This ratio is the current amplification factor α. For a common base circuit α can approach 1, but, because of the electrons neutralized in the base area, it is always actually less than unity. The collector current is directly dependent upon the emitter current, just as the plate current of a vacuum tube is dependent upon the grid voltage and, hence, the grid current. Thus any current variation in the emitter circuit produces an identical variation in the collector circuit.

The currents in the two circuits are nearly equal, but it will be remembered that the resistance of a P-N or N-P junction is much greater in the reverse direction than in the forward direction. This is the property which makes possible the transistor's ability to amplify. A signal applied in series with the very low voltage emitter produces a similar signal with nearly the same current but much higher voltage in the collector circuit. This provides voltage amplification. The collector resistance may be hundreds or thousands of times greater than the emitter resistance. Since power$=I^2r$, power is also amplified. Gains up to 100,000 are possible.

Variation of Circuits

There are many variations of the basic transistor and its connection as an amplifier. For instance, P type material can be used for the emitter and collector elements while using N type for the base. This requires only the reversal of the external polarities. Like diodes, there are two basic types of transistor construction: the point contact type and the regular junction variety.

The point contact type was developed first, and, because of its very low inter-electrode capacities, is still used for high frequency work, limits of 1000 megacycles being reached. The mass production of this type of transistor is difficult, though, because of the high precision necessary in spacing the electrodes. Therefore, point contact transistors have been superseded largely by the low frequency junction type, which has the added advantage of being able to handle more power. By careful alloying of germanium and silicon, the transient time of the atomic particles has been reduced until at present some junction transistors are capable of operation above 100 megacycles.

Aside from these physical considerations, changes in circuits and connections also vary the charac-

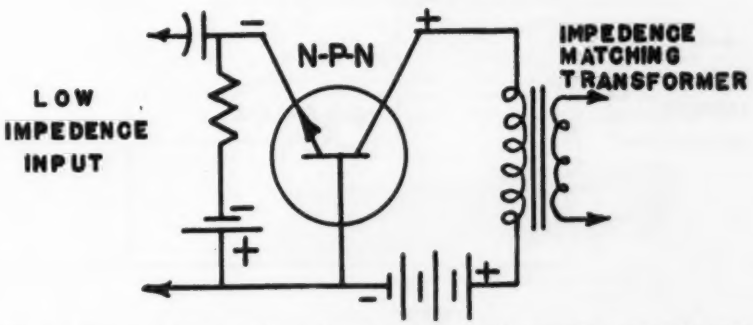

Fig. 4 **A common base transistor is shown here as it would appear in a practical circuit including a provision for matching its high output impedence to the input of a following stage.**

teristics and specific applications of transistors. It has been shown that common or grounded base connections produce low input and high output impedances. Since α depends on good impedance matches, an interstage matching transformer is needed to hook up several amplifiers in series or cascade. A typical common base circuit is shown in Fig. 4. Depending upon the way in which its terminals are connected, however, a transistor may be used in any of three different ways. When, for instance, the emitter is made the common element, as in Fig. 5, an entirely new set of conditions exists. The input impedance is raised (about 250–1500 ohms) but is still lower than the output impedance (.25–1.25 megohms). In this circuit the base becomes the input element and floats at a constant potential, usually that of the output of the preceding stage.

A small base input current of a few microamps causes a relatively large collector current of several milliamps, as opposed to the almost equal input and output currents in the common base circuit. The base-collector current amplification factor β is many times the α rating. The common emitter circuit corresponds roughly to a grounded cathode vacuum tube circuit. Because of the high gains obtainable, it is the most widely used hookup. The common emitter circuit is the only one in which the output current is out of phase with the input current. Thus only negative feedback is possible, and no oscillation can occur. This circuit will not work as an oscillator but is used almost exclusively in high-gain amplifiers.

The common collector is often used for special purposes even though it has relatively low power gains. It has a rather high input and very low output impedance. Its frequency response range is greatly limited by the fact that both impedances vary with frequency and load variations. Its low output impedance is often used, however, in miniature radios because it can directly drive a low impedance speaker coil without a bulky audio output transformer.

New Uses

The development of semiconductors is still in its infancy. It has been only a decade since the transistor effect was first discovered. Every day new uses are found. A transistor, for example, is now often used as an oscillator by coupling a portion of the output power to the input. In such applications it may soon replace a whole line of oscillator vacuum tubes.

The effect on the inter-electrode capacitance of varying the base bias leads to a possible use as a miniature variable condenser. A three terminal semiconductor rectifier can be made to conduct in both directions by proper biasing of the third terminal. This can be used to replace the thyratron tubes used in electronic switching, and could be especially important in computer gate circuits.

In the application of the Seebeck and Peltier effects, semiconductors make the best thermocouples for electronic heating and refrigeration. Light-sensitive semiconductors are finding use in phototubes. Meanwhile research goes on to improve devices already available and to lower their prices.

In spite of their popularity, transistors and semiconductors do not solve all problems. They will probably never replace all vacuum tubes. Certain types of tubes, such as ceramic power amplifiers and high power microwave oscillators, are only now being developed themselves with no immediate prospect of replacement. In less than fifteen years, however, semiconductor devices have progressed to their present position: that of potential replacements for nearly all rectifier, amplifier, oscillator, and counter vacuum tubes.

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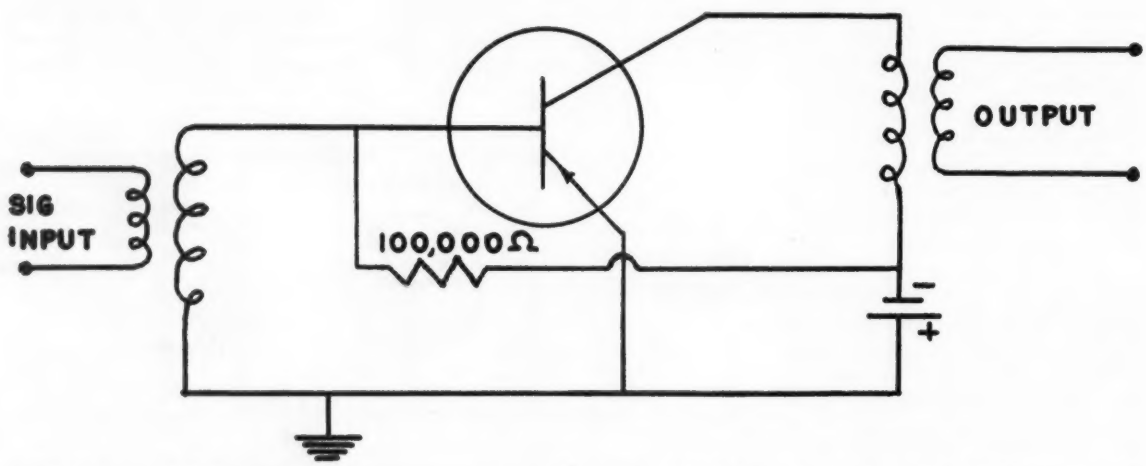
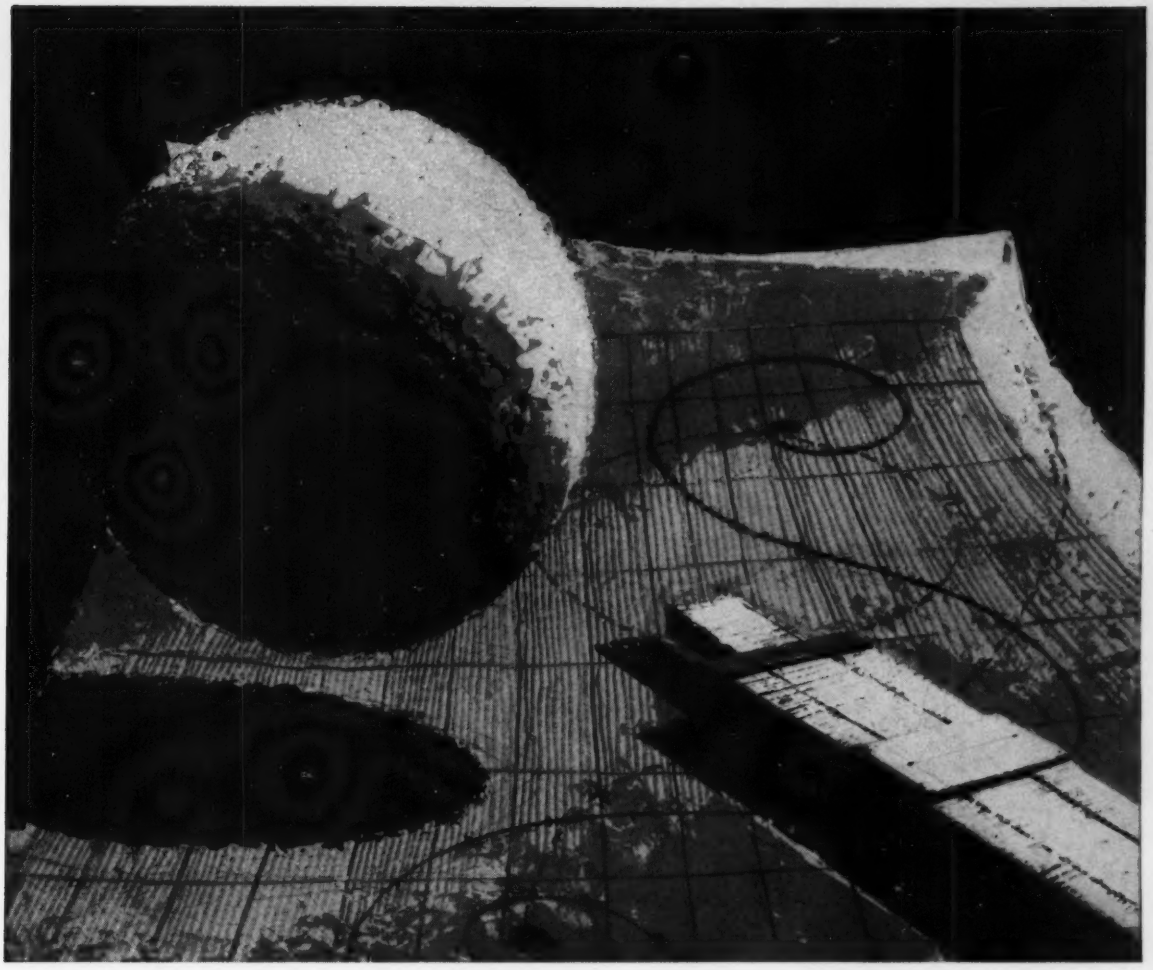


Fig. 5. **This simplified diagram shows the common emitter amplifier circuit which finds wide application due to its high current gain.**



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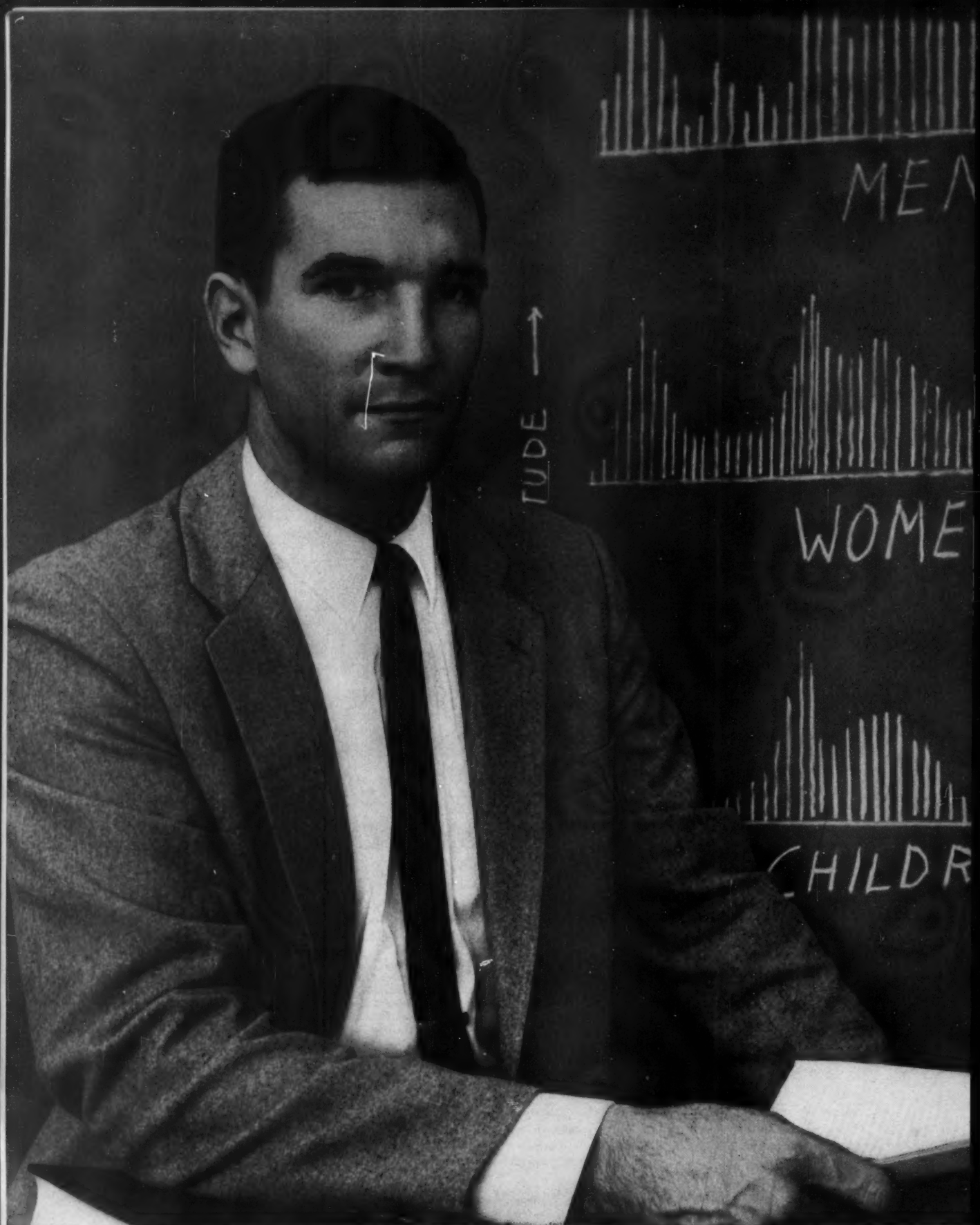
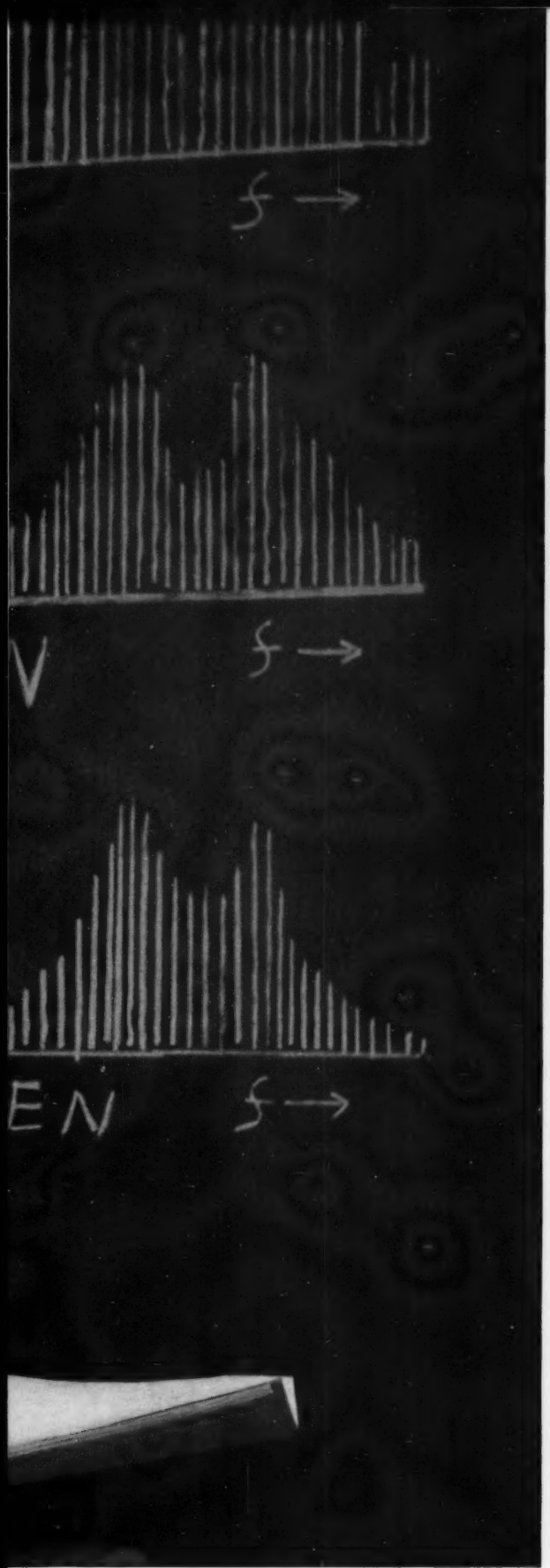


James Elam (M.S., Purdue '59) is studying various techniques of speech analysis at IBM. The objective of this work is voice-machine communication.



He's breaking through sound barriers to find new applications of human speech

It is believed that once clear, distinct signals can be obtained from human speech sounds, the human voice can be used for direct communication with machines. James Elam is working in this direction.

Voice-Machine Communication Problems

The problems involved are formidable. Machine "understanding" of human speech will be limited by both the sensitivity and the number of electronic "recognizers" of speech-sound patterns that can be built into the machine. To further complicate matters, the human voice is capable of making an almost infinite variety and subtlety of sound patterns. Only in theory could a machine be built that could recognize all of them.

A Solution in "Phonemes"?

To further this work on voice-machine communication, James Elam is studying various techniques of speech analysis. In one scheme, recordings are made of voices reading words. These are then examined in their frequency spectrum, and a power within discrete bands is plotted. The plots, or spectrograms, are used to break down words into basic sounds called "phonemes." Each phoneme has a separate and distinct pattern and is capable of giving a clear signal. It is hoped that these signals can be used to communicate directly, through an audio input, with machines.

Fascinating Assignments

Because of its exciting future possibilities, James Elam finds his work fascinating.

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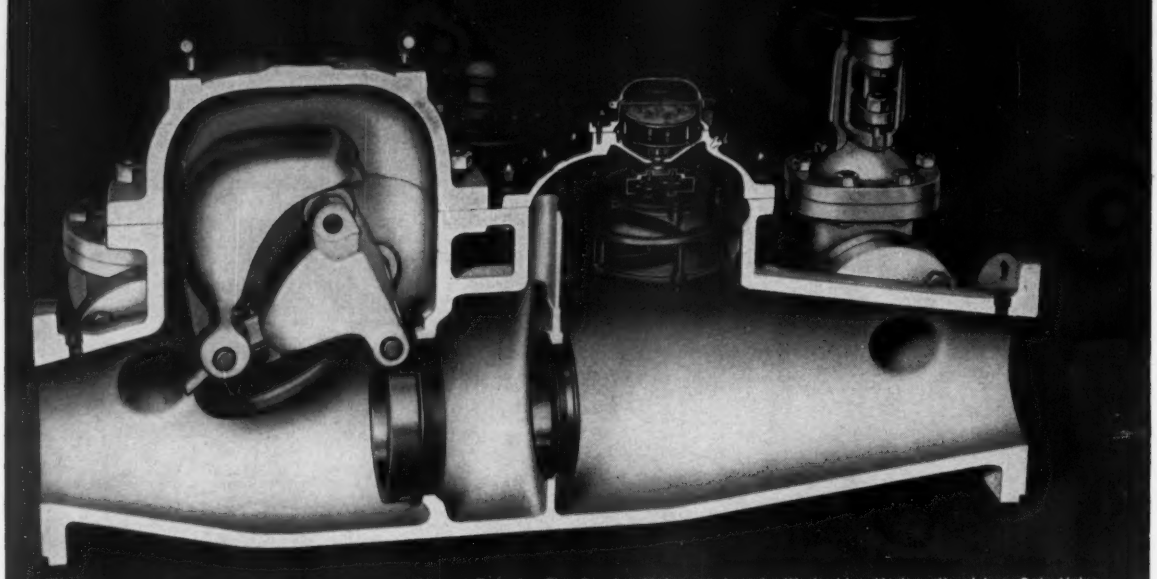

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Man's biological limitations cause problem of . . .

SURVIVAL IN SPACE

by Gerald Rappe, ChemE '62

Is the human body with its amazing complexity capable of reaching the distant planets, or are there too many unknowns for even the physicist, chemist, biologist, astronomer, meterorologist, and engineer working together to solve? At this time the answer is still in doubt.

What are the problems in making manned space flight a reality? Unfortunately, the human body is not well suited for space travel. The spaceman will need a constant supply of oxygen; he can be neither accelerated nor decelerated too rapidly. He must have nourishing food, and he should have a certain amount of physical and intellectual activity. Provision must be made for removal of carbon dioxide from the air, and there must be proper regulation of temperature and humidity. This is only a small part of the problem. What effect will cosmic radiation have on him? How will he react under a condition of weightlessness? Will he become disorientated? Will he suffer from delusions and hallucinations? Will he stand the stress of his long period of isolation? These are only some of the problems concerning manned space flight which face the scientists of today.

Carbon Dioxide—Oxygen Cycle

On earth, we inhale oxygen and exhale carbon dioxide, and no particular attention is paid to the cycle. In a spaceship, this balance is vital. As we exhale carbon dioxide, we must have some method for its removal, for it is toxic even in small concentrations. Lithium, barium, or sodium hydroxide could be used to remove carbon dioxide from the air. However, over an extended period of time, the surface area, and hence the efficiency of these materials, decreases. A more promising proposal is to simulate the earth's oxygen-carbon dioxide cycle in the space ship by the process of active photosynthesis. Vegetation aboard ship would remove the carbon dioxide from the air and replace it with oxygen. One plant, algae, seems especially adapted for this job, because it will occupy a small area and still supply enough oxygen for respiration. Other reasons for its use will be examined later.

Toxic Body Products

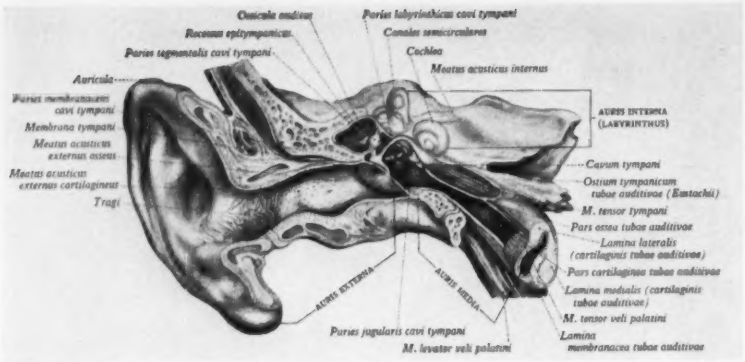
Closely related to the problem of carbon dioxide-oxygen balance is the formation of toxic substances by the body. Here again this is no problem on earth, but it must be considered if these substances are allowed to accumulate over an extended period of time. Carbon dioxide is a major constituent of the air we exhale. Blood liberates gaseous products nitrogen and acetoacetic acid. Urine, though largely non-volatile, liberates ammonia and ethereal sulfates; while in the faeces, volatile constituents are carbon dioxide, nitrogen, oxygen, hydrogen, and methane. In the solid portion of the faeces are toxic substances indole, skatole, hydrogen sulfide, phenol, and various amines. This strongly suggests the need for some sort of air-conditioning which would remove both the noxious gases and the odor. Activated charcoal may find some application in removing odors, while algae could fulfill a second important function by using the solid metabolic products as fertilizer.

Food—A Problem Aboard Space Ship

Feeding our space traveler will also present problems. The question arises: Why not cook food? The answer is twofold: Cooking food produces toxic substances and also decreases the available supply of oxygen. Acrolein, a toxic substance produced by heating fats, cannot be tolerated in a concentration of more than one part per million. Food dispensers aboard the spaceship must be able to store large quantities for long periods of time and prevent contamination, spoilage, and accidental spillage. Drinking from an open tumbler under weightless conditions may result in drowning a spaceman. Therefore, squeeze-type bottles similar to plastic ketchup bottles will be used. The food problem would be greatly simplified if man would be content with eating our old panacea, algae. This green plant has a very high food value and is rich in proteins, fats, and carbohydrates. It seriously deserves our attention as an outer space nutrient.

Gravitational Phenomena

An earthman will face vastly different gravitational phenomena in his flight to outer space. On first leaving earth, he will experience a tremendous force of up to twenty times his own weight. This is the force necessary for the ship to escape the earth's gravitational field. He will be unable to move at all and will have great difficulty



The human ear. The fine hairs near the cochlea of the ear are those which will be affected by a changing gravitational field.

breathing. If hypoxia (an insufficient supply of oxygen) sets in, he will black out. Rapid deceleration is also a potential source of danger to the space traveler. A rocket sled test in 1955 by Col. Stapp nearly did permanent damage to his eyes. The sled, which had been traveling at 700 mph, was rapidly decelerated. The resulting forces acting on him were so great that he had two black eyes. Only after a week of rest did his eyesight return to normal.

Effects of Isolation

Another difficulty our spaceman will face will be the emotional strain caused by long periods of isolation. Associated with this is the so-called "Break-off Phenomenon," a by-product of isolation and boredom. It is a trance-like sensation in which the spaceman becomes totally uninterested in survival. Deep-sea divers often have a somewhat analogous experience. Jacques-Yves Cousteau, a French writer, calls this underwater counterpart "Rapture of the Depths." Scientists say the break-off phenomenon can be averted by providing mental and physical activity.

Weightlessness

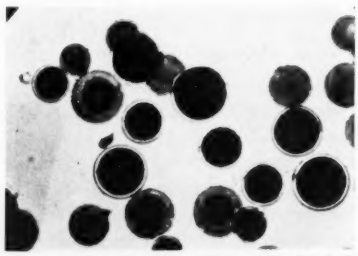
Probably the biggest unknown is how man will react under weightlessness. This phenomenon, also called zero-gravity, will exist after the space ship escapes the earth's gravitational field. It can be attained for limited periods of time on earth by flying through certain parabolic paths. The problem of weightlessness has both physiological and psychological aspects. Under this new condition, our space traveler will have to make quite a few adjustments. Food will have to be chewed very carefully. Well-chewed food can be handled quite adequately by peristaltic action, whereas unchewed food may cause choking. Liquids must be swallowed slowly, and the maximum amount per meal is still to be determined. Excessive liquid in the stomach is quite likely to produce another gastro-intestinal problem, that of weightless regurgitation. Further amplification is not needed, but it should be pointed out that this is but one part of motion sickness. Elimination of body waste solids should present no problem once sanitary human waste receptacles are developed.

Another area which must be considered is muscular activity. On earth, every movement we make is work done against the force of gravity. It is feared that under a condition of zero gravity, with so little work expended in movement, muscular coordination will seriously suffer. For example, a normal step on earth would result in a leap from one side of the space ship to the other. A sneeze would result in a man's being propelled against the opposite wall of the space ship. Suppose through some wonderful power of acclimatization man was able to master his movements under weightlessness. What would result when he returned to earth? This would probably be analogous to a baseball player who swings one bat during practice, but upon facing the pitcher must carry twenty bats. After weightlessness, man would feel as if he were walking around with hundred pound weights in either shoe. The question is will man be able to redevelop his muscular coordination after being exposed to weightlessness?

How will weightlessness affect man's orientation? Three systems in the body contribute to man's orientation; they are the visual, kinesthetic, and vestibular systems.

The kinesthetic apparatus consists of special receptors situated in muscles, tendons, connective tissue, skin, viscera, and nervous connections with the brain. The vestibular system consists of the paired small balance organs located in the inner ear and their nerve connections to the cerebral cortex, perception center of the brain. The otolithic organ in the ear is sensitive to linear acceleration and deceleration, while the three semicircular canals (which orient man to three dimensions) are sensitive to angular acceleration and deceleration. The otolithic organs and the kinesthetic organs are both activated by an external force such as gravity or an accelerative or decelerative force. Since in outer space no external forces would be present, it is expected that these systems would behave quite differently.

Disorientation can also be explained by considering the action of the liquid in the inner ear. When we stand erect, the liquid in the ear comes in contact with extremely fine hairs on the lower surface of the cochlea. When we stand on our head, the liquid comes in contact with the upper surface of the cochlea. This differentiates up from down. However under zero gravity the liquid could come in contact with both the upper and lower surfaces simultaneously. This unfortunately will bewilder our spaceman. Scientists intend to modify this problem by using a very obvious visual aid;



Dr. Kingsbury, Botany Dep't. C.U.

This is a form of algae, haemato coccus, which may allow an interplanetary voyage.

they plan to paint the ceiling of the space cabin one color and the floor another.

Temperature in outer space ranges from –67C to 26,000°C. This is not quite as serious as it would seem, because molecules in space are very far apart and hence the only effective method of heat transfer is radiation through the propagation of electromagnetic waves. A shiny metallic surface on the space ship would reflect these waves and tend to minimize temperature changes.

Inside the spaceship zero gravity does strange things with heat transfer. Under this condition convection will cease. A consequence of this is that the body cannot be cooled through perspiration or evaporation. Air ventilation is deemed mandatory since gases will not mix well and there might be localized deficiencies of oxygen which could cause suffocation. At high temperatures, protective clothing will be necessary. Clothing with a metallic lustre that will reflect heat would be effective, as would clothing that precools the skin (such as by wetting).

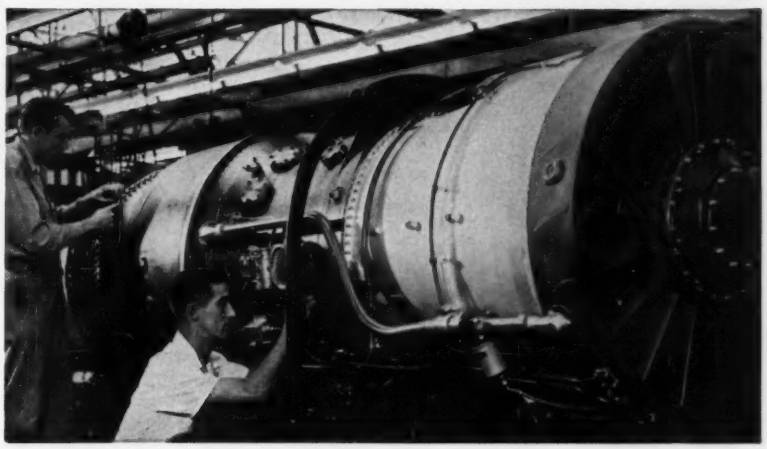
How will meteors affect our space passenger? Large meteors are not the only ones which cause trouble. Very small meteors will create a puncture perhaps the size of a small pea. Crew members have only fifteen seconds before they succumb to hypoxia. Therefore emergency apparatus must be available. If hit by a large meteor (some weigh hundreds of tons and travel at 36,000 mph), emergency apparatus would be of little use. Collision with meteors is possible, but only remotely probable. Until more information is gained about their relative occurrence, they will remain an occupational hazard.

Cosmic Rays

What effects will cosmic radiation have? Primary cosmic radiation is the assemblage of all radiations whose individual particle energies exceed some arbitrarily selected value, usually 2×10^6 electron volts. Cosmic radiation is a conglomeration of atomic particles having a frequency of the order of 10^{24} cycles per second and nearly attaining the velocity of light. Such radiation is known to have a genetic effect. Experiments show that it induces mutations during mitotic cell division. Mitosis is the process by which a human cell divides into two new cells, each exactly like the parent cell. If, during the process of cell division, these high frequency particles bombard the cell, the result is an unequal distribution of chromosomes. This produces two mutant or diseased cells. These cells then divide, each producing more diseased cells. The final result is not attractive. Cosmic radiation may also cause severe damage in the hypothalamic region of the brain by changing the complex patterns of electrical activity of the brain. A great deal more information is needed on this topic as to where and how much radiation is to be expected. Scientists are presently attempting to devise methods by which the spaceman could be shielded from these powerful radiations. One promising possibility is to deflect the particles by inducing a magnetic field around the spaceship.

Ten years ago, a flight to the moon was in the realm of science-fiction. Now we are on the threshhold of putting man on a distant planet. A great amount of research must still be done. Myriad unknowns must be intelligently investigated and understood, and complex problems must be solved. Propelling man into outer space is a challenge to man's brainpower and imagination. One of the motivations to space travel is embodied in this statement by the late Albert Einstein: "The fairest theory we can experience is the mysterious. It is the fundamental emotion which stands at the cradle of true science. He who knows it and can no longer wonder, no longer feel amazement, is as good as dead."

Man is not a fish, but he can swim; he is not a bird, yet he has learned to fly. Similarly, man's body is not suited to space travel, but with the astronomer, biologist, and engineer working together, man will also reach the distant planets.



Fafnir Ball Bearings help turbojets set new performance records

A recent article in a leading newspaper quoted airline executives to the effect that Pratt and Whitney Aircraft jet engines are proving to be the most reliable ever put into commercial planes.

In designing these jet engines, Pratt & Whitney Aircraft looked to The Fafnir Bearing Company as a major source for main rotor thrust bearings, generally regarded as among the critical engine components, and one of the most exacting to produce. Each ball bearing is custom-built and rigorously tested. Tolerances are held to the millionths-of-an-inch.

P&WA turned to Fafnir because of Fafnir's long experience in the design and development of aircraft bearings. Fafnir established an aircraft division thirty years ago, the first in the industry, and through it, is keeping pace with the revolutionary changes in aircraft design.

To help solve this and other ball bearing problems, Fafnir maintains the most up-to-date facilities for metallurgical research, and bearing development and testing. Fafnir may be able to help you some day. Worth bearing in mind. The Fafnir Bearing Company, New Britain, Connecticut.

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In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, Director, JPL

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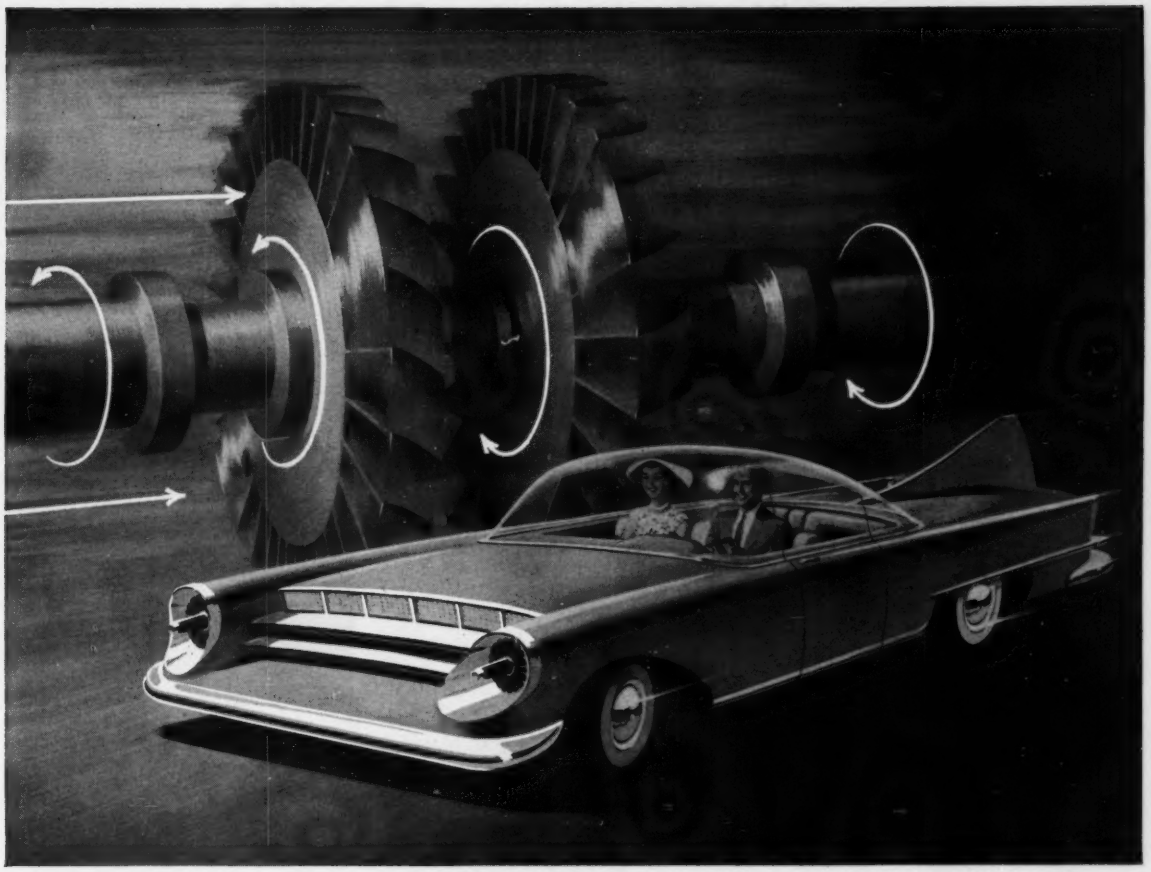

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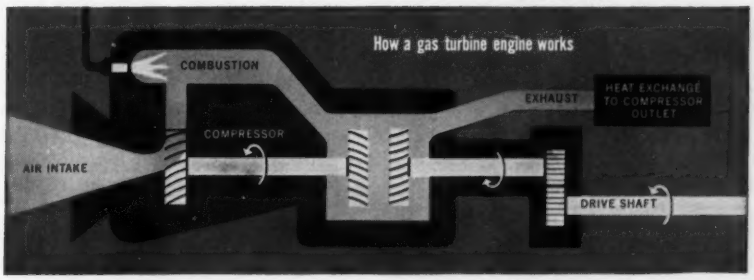

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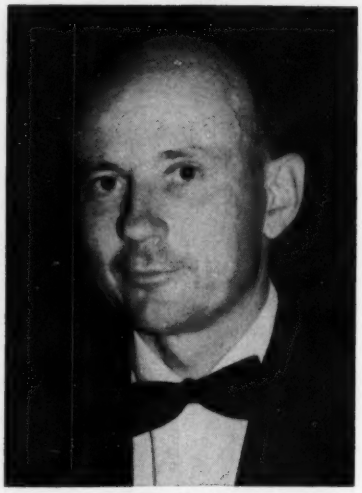

S. D. Teetor

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S LETTER—

In the Spring of the year they say that a young man's fancy lightly turns to thoughts of love. In the Spring of the year the thoughts of an organization turn towards a recapitulation of what their achievements have been for the past year. This message shall serve as a brief resume of some of the happenings of the Society, since the start of the fiscal year. The Society is organized on a basis which starts on the first day of July, the middle of the calendar year, rather than on the first of the calendar year.

This past Fall the first nationwide meeting was held. The location was, most naturally, at Cornell. Representatives from the different Chapters of the Society attended the meeting and, at appropriate points Dean Dale Corson and Assistant Dean, John McManus and others, were present. As an outgrowth of that meeting the Society has definitely decided to hold annual meetings of the officers at least once a year, in Ithaca. This will definitely improve the liaison between the Society and the College as a whole and it should enhance both the University and the Society.

In one of the previous issues, I discussed on this page the intention of the Society to establish additional Chapters throughout the country. The response has been favorable and I can now safely announce that at least two Chapters will be organized this year. Thanks to the intensive efforts of our Secretary-Treasurer, Don Haude, an organizational kick-off meeting is being held in Washington, D.C., probably the latter part of April. Assistant Dean, John McManus, from the University, will be present to help us have a successful meeting. A second Chapter, at the present time referred to as the Bay Area Chapter, is also in the process of being organized. Norm Bergrun, C.E. '43, of Palo Alto, California, is the motivating force of the Society behind this Chapter and the initial meeting is expected to take place in May of this year.

There is one item which we have attempted to accomplish, but with which we have not met with too great a success. This is the setting up of Cornell Society meetings to be held as an integral part of the program of the different Engineering Societies at the time and place of their conventions. These meetings need at least one man from each of the Societies to act as the liaison for the Cornell Society with the Technical Societies and to actively run the luncheon meeting during the main Society convention time. Any members that would be willing to help out on this are urgently requested to contact the writer.

Stephen D. Teetor '43, *President*

ALUMNI ENGINEERS

Gustav J. Requardt, C.E. '09, has been elected an honorary member of the American Society of Civil Engineers at the 1959 Annual Convention of the Society.

Mr. Requardt is a partner in the Baltimore firm of Whitman, Requardt, and Associates. He has had several consulting assignments, including one for the State of New Jersey on Deleware River diversion and one for the Army Corps of Engineers on flood pumping of the Susquehanna River.

Mr. Requardt has made great contributions to his profession in his work on the ASCE Manuals dealing with the private practice of civil engineering. He has been extremely active in the ASCE and is a past president of the Cornell Society of Engineers.

Charles B. Palen, B.S.M.E. '13, retired recently after forty-six years with the Newport News Shipbuilding and Dry Dock Company. Mr. Palen joined the Company immediately after his graduation from Cornell. He was made assistant superintendent of the Machinery Installation Division in 1927 and became superintendent of the Division in 1936.

Mr. Palen moved into nuclear propulsion activities in 1955 when he was made manager of the Atomic Power Installations Division, which was organized to carry out the Company's part in the Atomic Energy Commission's A1W project. He served as vice-president in charge of operations for the Eastern Idaho Construction Company, a subsidiary of the Newport News Shipbuilding and Dry Dock Company, founded to carry on the work of the A1W project. The aim of the work was to build a full-scale nuclear power engineroom, a prototype for the engineroom on the aircraft carrier *Enterprise*, now being constructed at Newport News.

James N. Ottobre

Rafael R. Ramirez, M.E. '24, has been appointed assistant executive director for power operations of the Puerto Rico Water Resources Authority. Having worked for the public utility company since his graduation from Cornell, Mr. Ramirez served as head of the Power Division for thirty-two years.

Rafael R. Ramirez

Richard R. Lyman, M.C.E. '03, Ph.D. '05, was the subject of articles in the July, 1957 and July, 1958 issues of the *Sons of Utah Pioneers News* and in the spring, 1959 number of *The Gear* of Theta Tau. A consulting engineer, Mr. Lyman created the modern Lyman street numbering system that is spreading throughout the West. He was a consulting engineer on Chicago's sewage disposal system, the Colorado River aqueduct, and the Grand Coulee Dam; these three projects were among the seven selected by the American Society of Civil Engineers as the "modern civil engineering wonders of the United States."

Jes J. Dall III, B.S.M.E. '43, has been appointed general manager, electric welding, for the Linde Company Division of Union Carbide Corporation.

Paul P. Titchener

Paul P. Titchener, M.E. '13, president of E. H. Titchener and Co. of Binghamton, was recently presented with the 1959 Hall of Fame Congress Award by American Legion Post 80. The award was in recognition of his outstanding work in the establishment of Broome County Community College. Mr. Titchener was appointed chairman of the first board of directors of the College by Governor Dewey in 1946. He has also been president of the Binghamton Chamber of Commerce, chairman of the Citizen's Committee for Urban Renewal and Development, and a member of the executive committee of the Valley Development Foundation.

James N. Ottobre, B.E.E. '49, has been named manager of the development laboratories at Lockheed Electronics Company's Stavid Division in Plainfield, N.J. Mr. Ottobre joined Stavid after graduating from Cornell and served as manager of the shipboard electronics department from 1955 until his recent appointment to the development laboratories.

The Cornell Society of Engineers and the Cornell Club of Cleveland will sponsor a dinner May 2 at 6:00 P.M. at the Cleveland Engineering and Scientific Center. Dean Dale R. Corson and Assistant Dean John F. McManus will be the speakers.

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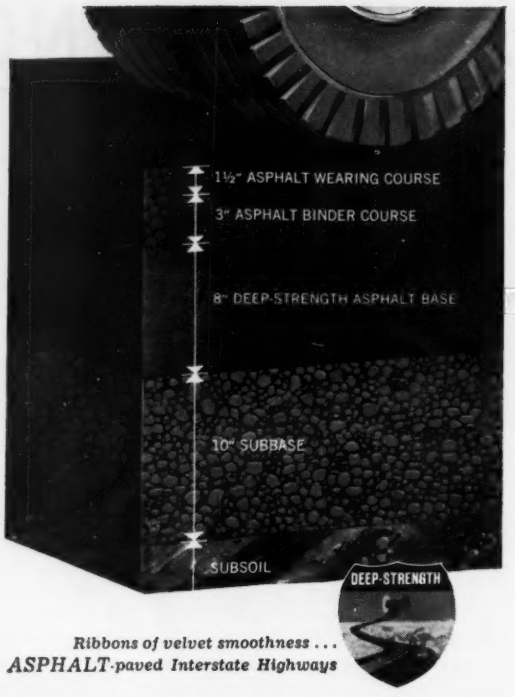

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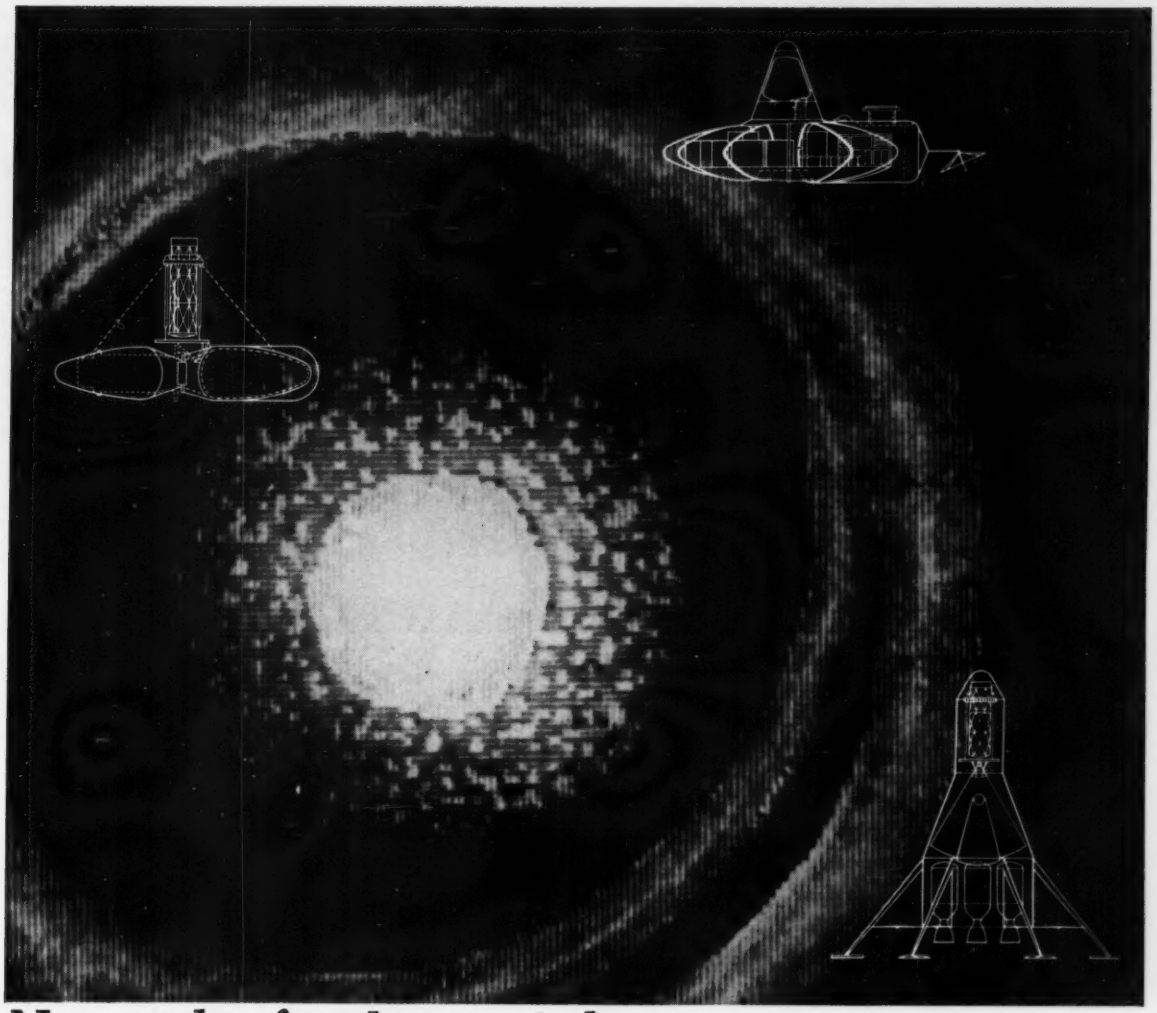

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Dr. Eugene Konecci, Head, Life Sciences Section, reviews a new concept in space cabin design with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

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COLLEGE NEWS

Edited by R. A. Stern, EE '63

WANG AWARDED EMANUEL VISITING PROFESSORSHIP

Professor Chao C. Wang, Sperry Gyroscope Company electronics expert, has been awarded the Victor Emanuel Distinguished Professorship at Cornell University for the spring, 1960 term.

The AVCO Manufacturing Corporation established the one-term visiting professorship in the College of Engineering at Cornell in the fall of 1957, to be known as the Victor Emanuel Distinguished Professorship, honoring Victor Emanuel, '19, who is a trustee of the University.

Prof. Wang, head of microwave tube research at Sperry, is the fourth recipient of the academic honor, awarded to "persons of broad technical competence whose interests extend into many fields of science and engineering." In keeping with the original intent of conferring the honor on distinguished men who would be "brought to the campus chiefly for their ability to stimulate the (Cornell) staff both academically and professionally," the honor has gone in the past to Theodore von Karman, leading aerodynamicist; Balthazar von der Pol, expert in applied mathematics; and Olof E. H. Rydbeck, Swedish authority on upper atmosphere physics.

Dr. Chao C. Wang, electronics expert from Sperry Gyroscope Company, is Victor Emanuel Visiting Professor at Cornell for the spring term, 1960.

Recipients of the award are not required to hold formal classes at the University, but they do conduct seminars for graduate students and give University-wide lectures. Most of their time is spent in study and consultation with University research personnel in both the theoretical and practical aspects of science and engineering.

A Sperry research scientist since 1946, Prof. Wang is known widely for his many basic contributions to the fields of electron physics and microwave tubes. His work on magnetic focusing systems for electron beams and electromagnetic interaction circuits made possible the construction of extremely high-power radars for United States defense.

Prof. Wang also developed mathematical techniques which permit electronic computers to yield engineering solutions to complex problems of microwave development.

Having graduated from Chiao-Tung University in Shanghai with a B. S. degree in 1936, Prof. Wang received M.S. and Ph.D. degrees in radio communications from Harvard University in 1938 and 1940.

A member of the American Physical Society and the American Association for the Advancement of Science and a fellow of the Institute of Radio Engineering, he has published a number of papers on electronic tube theory and holds several patents.

SUMMER SCIENCE PROGRAM DEMONSTRATES ITS WORTH

More than three-fourths of the thirty-four New York State high school juniors who took college-level courses under a special program at Cornell University last summer have won New York State regents scholarships. The program, a Summer Science Institute for Secondary School Students, was sponsored by the National Science Foundation.

Approximately sixty high school juniors and seniors were chosen from over 1600 applicants to take part in the Institute. Of this total, forty-three were from New York State. Nine of these people were either seniors in high school or were juniors who had been accepted for college after three years of high school. Of the thirty-four remaining students eligible for regents scholarships, twenty-seven were given the awards while four of the others were named as alternates. One participant, Stephen R. Chinn of Middletown, tied for first place in the regents competition with a score of 279 out of a possible 300.

TERRAIN AVOIDANCE SYSTEM FOR PLANES DEVELOPED AT C.A.L.

The Cornell Aeronautical Laboratory has developed an experimental automatic terrain avoidance system and will begin flight testing the equipment in the near future. The low-altitude automatic flight control system is being installed in an Air Force B–57B for flight evaluation of the equipment. To date, installation of initial instrumentation and special radar has been completed.

The automatic terrain avoidance system was developed under a program sponsored by the Wright Development Division of the Air Research and Development Com-

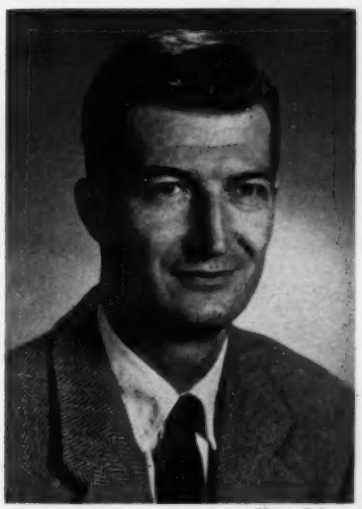

Photo Science

Thor N. Rhodin, associate professor of engineering physics, has been appointed to the faculty of the School of Metallurgical Engineering and will conduct a seminar in the physical chemistry of metals.

mand. Called Project Autoflite, the program has progressed from feasibility studies to instrumentation for flight testing over the past three years. The Project is an outgrowth of earlier Cornell Laboratory research on terrain avoidance which began in 1953.

M.E. SCHOOL RECEIVES UNRESTRICTED GRANT

Unrestricted grants totalling over $100,000 were distributed recently by Hercules Powder Company among thirty American colleges and universities. The $2500 awarded to Cornell went to the Sibley School of Mechanical Engineering and will be spent on research equipment.

On the theory that the educators themselves know what is best to strengthen the American educational system, the heads of the departments receiving grants are given complete freedom in the use of the funds.

Of the thirty-one grants awarded, nine were made to chemistry departments, twelve to engineering departments, three to mechanical engineering departments, one to a mining engineering department, and six to miscellaneous other departments.

ROLL-OVER SIMULATOR TESTS FOR INJURIES FROM SKIDDING

Test results released by the Cornell Aeronautical Laboratory and the Liberty Mutual Insurance Company indicate that a person riding in a car which rolls over suffers a potentially injurious head blow unless he is restrained by a seat belt or similar device.

A recently completed Cornell Laboratory research project, sponsored by Liberty Mutual, investigated automobile roll-over crashes under controlled laboratory conditions. Using a CAL-developed roll-over simulator, scientists studied the motion and impact of passengers during such crashes.

The roll-over simulator consists of a standard model 1956 car body mounted between two turntables which rotate the car ninety degrees or more from horizontal at controlled turning rates. The attitude of the car with respect to the ground can also be changed to simulate side rolls or end-over-end crashes.

For the tests, dummies scaled to represent the average adult male and a six-year-old child were placed in the front seat of the roll-over car. Their heads were chalked to mark impact points and a high speed camera recorded their motions and velocities.

The tests conducted by CAL's Vehicle Dynamics Department showed that the first ninety degrees of automobile roll-over determines the directions, velocities, and impact points of the occupants. It was found that the driver or his passenger invariably receive potentially injurious head blows against the side or roof of the automobile unless body restraining devices such as seat belts are used. Such devices proved extremely effective in preventing the head from striking the vehicle's interior.

On the basis of the roll-over studies, CAL scientists recommended that the interior sides and roof of automobiles be padded to reduce injury potential. They also suggested that the steering wheel and post be redesigned to eliminate them as an injury hazard and that automobile roof construction be strengthened considerably to avoid cave-ins during roll-over.

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A member of Belle Aire Yacht Club, Ed leads a pleasant life afloat and ashore with his wife and two boys.

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TECHNIBRIEFS

Edited by D. J. Martin, ME '62

NEW SENSITIVE TV CAMERA TUBE INCREASES STUDIO FLEXIBILITY

A new type of television camera tube requiring only one-tenth the amount of light needed by conventional camera tubes has been developed by General Electric. The new tube is expected to cause many television innovations in both color and black-and-white.

The key to the unusual performance of the new tube lies in the fact that G.E. scientists have been able to devise a method of manufacturing films of magnesium oxide only two millionths of an inch thick. If 1,500 of these films were stacked, their total thickness would be about that of a human hair. It is this "target" film which performs the crucial function of transforming light impulses into electrical energy in a manner suitable to television broadcasting.

The new tube is expected to increase greatly the flexibility in studio programing since it does not require complete base-light flooding of the scene. The tube also offers advantages in resolution and depth of field. Local demonstrations in about twenty-five major cities are to feature live models and action scenes technically arranged to provide a direct comparison between the new super-sensitive tube and standard models.

NEW COMPUTER PROGRAM AIDS SPECIALIZED CALCULATING

The National Bureau of Standards has developed a general-purpose program which enables scientists to apply high-speed computation techniques directly to many of the problems arising in research. This program, called Omniform I, was designed to eliminate some of the delay caused by a wide variety of tedious computations which, because of their ad hoc character, are not usually programmed.

Omniform I is an interpretive program which enables even a user unfamiliar with computer programming techniques to instruct the machine to perform specialized calculations. Although this program was created primarily to meet the needs of workers in thermodynamics and molecular physics, the mathematical operations involved are applicable to calculations in many fields of physics, chemistry, and engineering where properties of materials or other tabular data are required as a function of one or two variables.

The program has anticipated a wide variety of common algebraic manipulations. The function types built into the program are identified and called for by numbers similar to the stock numbers used in shoe stores to identify shoe styles.

At present the program contains sixteen types of functions, including power series, natural and common logarithms, exponential terms, six trigonometric functions, and six hyperbolic functions.

Omniform is primarily a table generator. It can produce a table of fifty different functions for each of one hundred arguments. Among the tables which have been computed on Omniform are the following: ideal gas thermal functions for neon and electrons; anharmonic corrections for diatomic molecules; vapor pressure of solid nitrogen; virial coefficients for nitrogen gas; negative exponentials corresponding to certain atomic energy levels; polynomial substitutions; and table conversions of units.

PHOTHERMIC IMAGE CONVERTER EXHIBITS HIGH SENSITIVITY

A new infrared system sensitive enough to see moving objects near room temperature has been developed by scientists at Westinghouse Research Laboratories. Known as the phothermic image converter, the all-electronic device changes the infrared radiation emitted by an object into a visible picture on a television screen.

In general, infrared systems operate by sensing the heat energy radiated by a body and converting it, by means of some form of heat-sensitive detector, into equivalent electrical signals that can be amplified and made visible to the human eye. The traditional method has been to use a sensitive crystal or infrared cell to detect the radiation and a mechanical scanning system to make the image visible. The new approach entails an all-electronic imaging system. Such a device has the potential advantages of faster response, higher sensitivity, and better picture detail.

The system is sensitive enough to detect moving objects near room temperature when they exhibit temperature differences of approximately 20°F. This is just about the spread between the temperature of the human body and that of the average living room. In addition, the system is fast enough to follow the movement of the objects with the same speed as a normally visible object is followed by the unaided human eye.

The key component in the newly announced system is a unique infrared-sensitive detector, or retina. The retina is a three-layer sandwich only a few millionths of an inch thick. The center layer of the sandwich is a support film of aluminum oxide about one millionth of an inch thick. This film is made by chemically dissolving away all of the aluminum metal in a piece of suitably treated household aluminum foil, leaving only the thin layer of aluminum "rust" which coats the foil's surface.

The front surface of the oxide support film is coated with an even thinner layer of nickel, deposited in such thickness that it strongly absorbs infrared radiation. The back surface of the film is coated with a thin layer of a photoemitting material called cesium bismuth—a chemical compound capable of releasing electrons when light shines upon it. Of key importance is the fact that the photoemitter's ability to release electrons under the stimulus of light varies with its temperature, changing 2 or 3 percent for every degree its temperature changes. To increase the over-all sensitivity and performance of the detector, it is cooled to a temperature of about –180°F.

The infrared radiation from an object is focused on the heat-absorbing layer of the retina, forming a temperature pattern of the scene. This temperature pattern is transferred through the thin support

layer to the photoemitting surface, where it can be perceived simply by scanning a spot of light across the surface. As the light spot scans the photoemitting surface, the number of electrons flowing from any point on the surface is in exact conformity to the heat pattern on it. These electrical signals are then amplified and fed to a standard television picture tube, where a visible picture appears. In this way, a point by point description of the temperature scene is created on the television screen.

BUREAU OF STANDARDS USES NEW COMPUTERS TO SELECT TARGETS

The National Bureau of Standards is conducting a research program aimed at helping defense weapons to put each shot where it will be most effective.

A basic problem of target selection arises when several potential targets come within range of one weapon. The velocities of the attackers, their distances from the defended area, and various other factors must be weighed in deciding which target is most important. The function of a selection rule like the one the Bureau of Standards is attempting to construct is to combine all the relevant factors into a single composite criterion, which then yields an unambiguous choice of the best target among the attackers. Deciding precisely how the factors are to be combined requires a careful analysis of the relationship between the various criteria and the objectives of the defense.

Naturally, exact knowledge of the future course of the battle is not generally available. Probabilistic predictions, while theoretically possible, would require extensive calculations quite incompatible with the requirement for rapid decision-making. In the N.B.S. experiments, a high-speed computer mimics air defense battles and reports the results of the various possible target selections for a given situation. The computer moves the attackers and defense missiles along their paths, decides whether the defense missile has hit or missed, determines whether the attacking missile has reached its target, and keeps a detailed record of all the significant parts of the battle. With these computers, N.B.S. scientists hope to obtain a simple, general selection rule which could be applied effectively in actual battle situations.

PORTABLE MISSILE TOWER DEVELOPED FOR ARMY

A fifteen-story high portable missile service structure, believed to be the tallest and heaviest pneumatic tire-mounted structure in this country, has been developed for use at missle test sites. The portable service tower was developed by the U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, for use mainly in servicing missiles of the Redstone and Jupiter classes.

Previous missile towers have been either fixed or rail-mounted. The new 151-ft, 350,000-lb structure, however, is mounted on two base trailers of six wheels each. The outboard rearmost wheels are driven by an electric motor, and the front wheels are steered by hydraulically operated cylinders controlled by an electric sensing device running on a steering track.

After being positioned, the two crane hooks operating from the "hammerhead" top pick up the missile and set it on its launcher. Jack pads are lowered and the structure is lifted off its tires until the time for roll back.

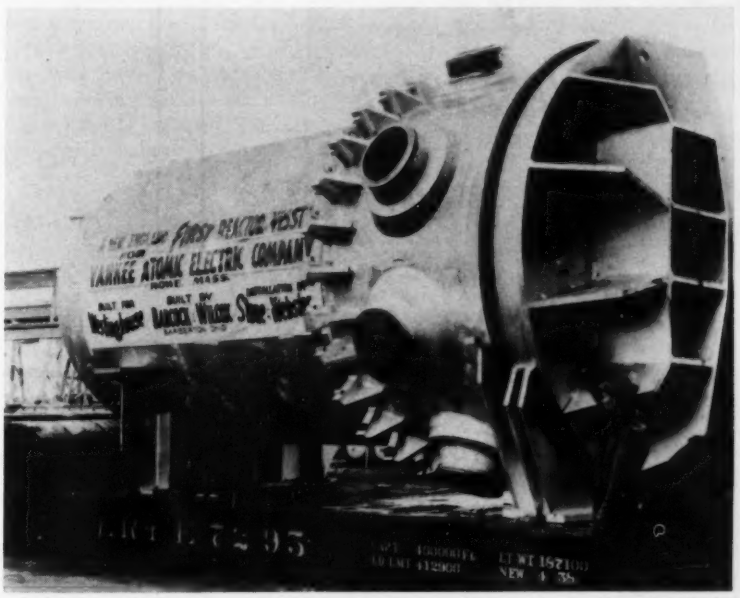
The tower has six adjustable platforms for use by engineers and scientists in preparing a missile for flight. It also has two elevators, a complete intercom system, and a "panic button" designed for use at the most critical moment of missile fueling. If a fire should start, a push of the button causes the platforms to back from around the missile, lifts the jacks up off the ground, and wheels the tower itself away from the fire. The entire tower structure can be dismantled into flat panels to be stacked in transport trailers for movement by aircraft or truck.

NEW ENGLAND GETS ITS FIRST REACTOR POWER STATION

Construction of New England's first nuclear electric generating station is to begin this year. The plant is to be built for the Yankee Atomic Electric Company in Rowe, Massachusetts.

The 165-ton reactor vessel to be used in the station was shipped recently from the Babcock and Wilcox plant in Barberton, Ohio, to the plant site in Massachusetts. The vessel, 27 ft long and 13 ft wide, was carried by a specially-built depressed flatcar three times the length of the ordinary freight car.

The new 134,000 kw plant will be of the pressurized-water type and will use slightly enriched U-235 as fuel.



A 165 ton nuclear reactor vessel starts on its way to Rowe, Mass., where the Yankee Atomic Electric Company is erecting New England's first atomic electric generating station. The reactor, 27 feet long and 13 feet in diameter, required a specially-built flat car three times the length of the ordinary freight car.

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A steam-propelled aeroplane was built in 1893 by Mr. C. A. Parsons of turbine fame. *London Engineering* describes it as an aeroplane of two wings and a tail built of a silk covered cane frame-work, the whole machine with its spirit lamp steam engine weighing only three and one-half pounds. It has made several successful flights of about one hundred yards.—*The Sibley Journal*, April, 1910.

The object of summer work for undergraduates is either to make money for the next University year, or to gain professional experience. It is nearly impossible to combine these two objects since experience and resulting skill are necessary to earn money. Therefore if the first consideration is a maximum saving at the summer's end, it is best to do what one is most skilled in doing. But if the object is professional advancement it is best to do that which produces a maximum result toward that end.

The graphical record of engineering ideas and the materialization of engineering ideas are fundamental to all engineering work. This means drafting and shop work. Experience comes fastest if one begins at the beginning and goes forward logically. It seems therefore that the greatest result would come from work in the drafting room or shop. The shop work may take the form of construction and this gives large returns, especially if it is construction of extensive engineering work.

Professional experience does not usually come fastest thru the actual work one does, but thru the larger work one sees done. The work in hand may be an unimportant detail, but the work in sight should be extensive and suggestive. Therefore summer work should preferably be in large establishments. The electrical student should not wire a house or test meters to get experience. The mechanical engineer should not work for a model maker. Both should get into the midst of some large engineering enterprise.

Summer work, whatever its object, should not cover the entire time between University sessions unless by fortunate chance it is health producing work in the open air. At least two weeks should be given to recreation.—*The Sibley Journal*, April, 1910.

. . . Of course there are men who are all the time on the watch for a soft snap, and there is a very much larger number who think they want to take it easy, but time and again you will find those of the latter class working hard and willingly under a good superior. We Americans are a nation of large talkers. We won't do this and we won't do that. We stand on our rights and assert our independence. But let there be something to be done and the first thing you know all are so busy doing it that the boast and talk are forgotten. This is the saving grace that has made us the greatest nation on earth and should keep us such for generations to come.—*The Civil Engineer*, April, 1910.

Within the past year and a half, the writer has employed 31 graduate engineers, about 24 of whom were out of college less than a year.

The disheartening truth gradually dawned upon the writer that scarcely one of these men could be relied upon not to make radical errors . . .

One graduate spent a week in looking for errors in his level lines in a desolate swamp, and when his original notes were sent to the office and checked, glaring errors in arithmetic were found in them...

And yet this corps was, on the whole, an excellent set of engineers, as young engineers go. Honorable, energetic, ambitious, willing to go into rough and thorny places —lacking only an appreciation of the importance of Precision, without which the work of an engineer is worthless unless checked.

An inexperienced college graduate should never be relied upon to make a survey and report a correct result until his work has been checked, cross-checked, and rechecked. — *The Civil Engineer*, April, 1910.

. . . Over one hundred men will take their degree this June, and although employing a graduate may not at first be a good financial investment, we quote a prominent engineer as saying, "Somebody had to give me my first experience, and I am ready to take my turn with an unexperienced graduate."—*The Civil Engineer*, April, 1910.

Tiny Tim is the name of the smallest engine in the world. It is made of gold and steel, and is so small that a common house fly seems large in comparison. It weighs just four grains complete, which is the weight of an ordinary match. It takes over 100 such engines to weigh one ounce, almost two thousand to weigh a pound, and more than 3,000,000 to weigh a ton.

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The engine bed and stand are of gold. The shaft runs in hardened and ground steel bearings inserted in the gold bed. These bearings are counterbored from the inside to form a self-oiling bearing. The fly wheel has a steel center and arms, with a gold rim, and the complete wheel weighs one grain.

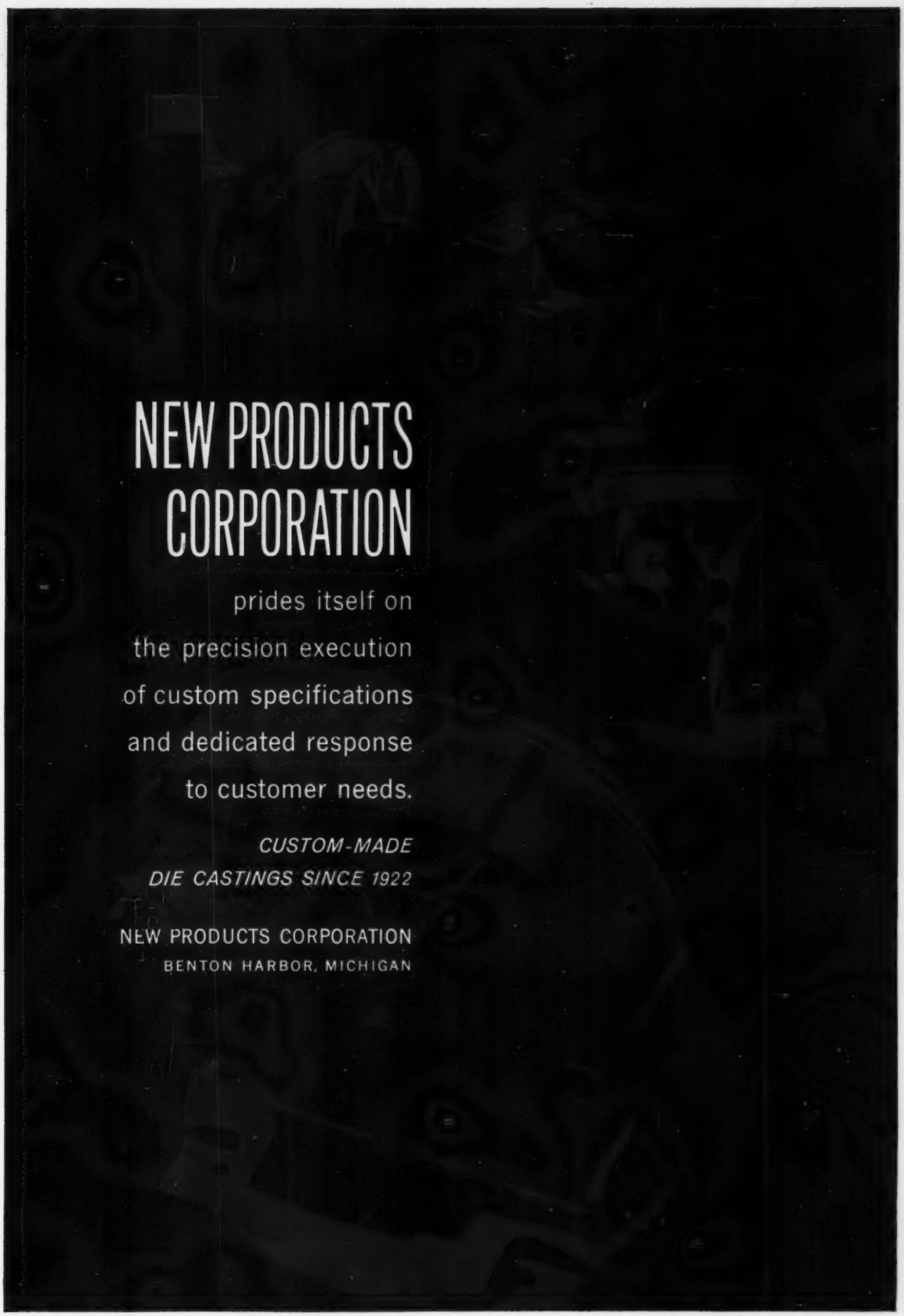
. . . The stroke is one thirty-second of an inch; bore, three hundreths of an inch. Seventeen pieces are used in the construction of this engine.

The speed of the engine is 6,000 revolutions per minute. When runing 100 a second, no motion is visible to the eye, but it makes a noise like the noise of a mosquito. The horsepower is one 489-thousandth of one horsepower.

Compressed air is used to turn it; and it may be of interest to note that the amount required to make it hum can easily be borne on the eyeball without winking. — *The Sibley Journal*, April, 1910.

Strongly does Bishop Williams bring before us the point that we must first be men, live the lives of men, and then be "Craftsmen." To live the lives of men is to live in sympathy with the surrounding world. It is to live a rounded life with broad interests, and not to be drawn into the narrow circle with the limits of a particular field of engineering as the circumference. The other professions have an advantage in this respect over engineering in that their work deals largely with men and the lives of men, while the engineer deals more with the material world. The engineer must therefore make an effort to interest himself in things outside his craft, and guard against getting into a rut.

Merely to make a living or to live for the pleasure of physiological functions is not life; these do not give satisfaction. After many other formulas of life have failed, one finds that the only formula that truly satisfies is to live for the realization of high ideals. This does not mean that such ideals will be fully realized in one's life; on the contrary, realized ideals become hindrances to further development, if considered as final goals. To live for ideal tendencies is a better definition of the purpose of life. *The Sibley Journal*—October, 1909.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STRESS *and* STRAIN . . .

The teacher was quizzing the class.

"Now who can tell me who gave us our nice schoolhouse?"

"President Eisenhower, teacher."

"That's right, Tommy. Who knows who gave us our beautiful parks?"

"President Eisenhower, teacher."

"That's right, Mary. And who gave us the bird and the bees, the flowers and the trees?"

"God did, teacher."

Voice from the back of the room. "Throw that Democrat outa here!"

* * *

Wife: "I thought you were going to the lodge meeting tonight?"

Husband: "It was postponed. The wife of the Grand Exalted Invincible Supreme Potentate wouldn't let him out tonight."

* * *

Boss: "Shame on you. Do you know what we do with office boys who tell lies?"

Boy: "Yes, sir, when they get old enough the firm sends them out as salesmen."

* * *

Luke: Gosh, but I'd like to make your dreams come true.

Lulu: I'll slap your face if you try it.

* * *

A lobbyist who was opposing any large state appropriation for Cornell approached a legislator who boasted of his self-education.

"Do you realize," asked the portly lobbyist gravely, "that at Cornell men and women students have to use the same curriculum?"

The legislator looked startled.

"And that boys and girls often matriculate together?"

"No!" exclaimed the lawmaker.

The lobbyist come closer and whispered, "And a young lady student can be forced at any time to show a male professor her thesis?"

The legislator shrank back in horror, "I won't vote 'em a damn cent!"

Due to circumstances beyond our control, the joke originally scheduled for this space was censored by the editor. Please stand by . . .

* * *

"See this jewelry?" said the sorority pledge. "It once belonged to a millionaire."

"Gosh," gasped an impressed sister, "what was his name?"

"Woolworth," the pledge replied.

* * *

A father was trying to point out the advantages of a good clean life to his son.

"Son, I know a man who doesn't drink, smoke, or chase women and he just celebrated his 100th birthday."

Small son: "How?"

* * *

"Did you get home from that party all right last night?"

"Yeah, except when I was going up the stairs in the dorm some idiot stepped on my hand."

* * *

Appearances are deceiving. Whenever you see a big house without any plumbing there is usually something behind it.

* * *

Police Sergeant: "College student, eh?"

Prisoner: "Yes, Sir."

Patrolman: "It's a stall. I searched his pockets and found money in them."

* * *

Two cockroaches were lunching in a dirty sewer. One was talking about the spotless new neighborhood restaurant, from which they had been barred.

"I hear," said one cockroach, "that the refrigerators shine like polished silver. The floors sparkle like diamonds. Why, the place is so clean—"

"Please, Please!" interrupted the second cockroach, "Not while I'm eating!"

A woman approached the pearly gates and spoke to St. Peter.

"Do you know if my husband is here? His name is Jones."

"Lady, we have lots of them here. You'll have to be more specific."

"Joe Jones."

"Lotsa those too. You'll have to have more specifications."

"Well, when he died he said that if I were untrue to him, he'd turn over in his grave."

"Oh, you mean 'Pinwheel Jones'."

* * *

A group of prohibitionists looking for the advantages of total abstinence were told of an old man 102 years old who had never touched a drop in his life. So they rushed to his home to get a statement. After propping him up in bed and guiding his feeble hand along the dotted line, they heard a violent disturbance coming from another room — furniture being broken, dishes smashed, and the shuffling of feet. "Good heavens, what's that?" they gasped. "Oh," whispered the old man as he sank exhaustedly into his pillows, "that's Pa—he's drunk again."

* * *

The little child was sitting demurely on the couch, watching her mother smoking a cigarette. Her little nose was wrinkled and in her pale blue eyes was an expression of disillusionment. Finally, unable to stand it any longer, she burst in her quavering falsetto:

"Mother, when the heck are you going to learn to inhale?"

* * *

A bored cat and an interested cat were watching a game of tennis.

"You seem very interested in tennis," said the bored cat.

"It's not that," said the interested cat, "but my old man's in the racket."

* * *

"Oh, here's the place Mother told me to stay away from—I thought we'd never find it."

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There's hardly a field on which you can set your sights where photography does not play a part in simplifying work and routine. It saves time and costs in research, on the production line, in the engineering and sales department, in the office.

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One of a series

Interview with
General Electric's Earl G. Abbott,
Manager—Sales Training

Technical Training Programs at General Electric

UNIVERSITY MICROFILMS
313 N. FIRST ST.
ANN ARBOR, MICH

Q. Why does your company have training programs, Mr. Abbott?

A. Tomorrow's many positions of major responsibility will necessarily be filled by young men who have developed their potentials early in their careers. General Electric training programs simply help speed up this development process.

In addition, training programs provide graduates with the blocks of broad experience on which later success in a specialization can be built.

Furthermore, career opportunities and interests are brought into sharp focus after intensive working exposures to several fields. General Electric then gains the valuable contributions of men who have made early, well-considered decisions on career goals and who are confidently working toward those objectives.

Q. What kinds of technical training programs does your company conduct?

A. General Electric conducts a number of training programs. The G-E programs which attract the great majority of engineering graduates are Engineering and Science, Manufacturing, and Technical Marketing.

Q. How long does the Engineering and Science Program last?

A. That depends on which of several avenues you decide to take. Many graduates complete the training program during their first year with General Electric. Each Program member has three or four responsible work assignments at one or more of 61 different plant locations.

Some graduates elect to take the Advanced Engineering Program, supplementing their work assignments with challenging Company-conducted study courses which cover the application of engineering, science, and mathematics to industrial problems. If the Program member has an analytical bent coupled with a deep interest in mathematics and physics, he may continue through a second and third year of the Advanced Engineering Program.

Then there is the two-year Creative Engineering Program for those graduates who have completed their first-year assignments and who are interested in learning creative techniques for solving engineering problems.

Another avenue of training for the qualified graduate is the Honors Program, which enables a man to earn his Master's degree within three or four semesters at selected colleges and universities. The Company pays for his tuition and books, and his work schedule allows him to earn 75 percent of full salary while he is going to school. This program is similar to a research assistantship at a college or university.

Q. Just how will the Manufacturing Training Program help prepare me for a career in manufacturing?

A. The three-year Manufacturing Program consists of three orientation assignments and three development assignments in the areas of manufacturing engineering, quality control, materials management, plant engineering, and manufacturing operations. These assignments provide you with broad, fundamental manufacturing knowledge and with specialized knowledge in your particular field of interest.

The practical, on-the-job experience offered by this rotational program is supplemented by participation in a manufacturing studies curriculum covering all phases of manufacturing.

Q. What kind of training would I get on your Technical Marketing Program?

A. The one-year Technical Marketing Program is conducted for those graduates who want to use their engineering knowledge in dealing with customers. After completing orientation assignments in engineering, manufacturing, and marketing, the Program member may specialize in one of the four marketing areas: application engineering, headquarters marketing, sales engineering, or installation and service engineering.

In addition to on-the-job assignments, related courses of study help the Program member prepare for early assumption of major responsibility.

Q. How can I decide which training program I would like best, Mr. Abbott?

A. Well, selecting a training program is a decision which you alone can make. You made a similar decision when you selected your college major, and now you are focusing your interests only a little more sharply. The beauty of training programs is that they enable you to keep your career selection relatively broad until you have examined at first hand a number of specializations.

Furthermore, transfers from one General Electric training program to another are possible for the Program member whose interests clearly develop in one of the other fields.

Personalized Career Planning is General Electric's term for the selection, placement, and professional development of engineers and scientists. If you would like a Personalized Career Planning folder which describes in more detail the Company's training programs for technical graduates, write to Mr. Abbott at Section 959-13, General Electric Company, Schenectady 5, N. Y.

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